

FOREST VEGETATION OF THE BIGHORN  
MOUNTAINS, WYOMING: A HABITAT  
TYPE CLASSIFICATION

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1975

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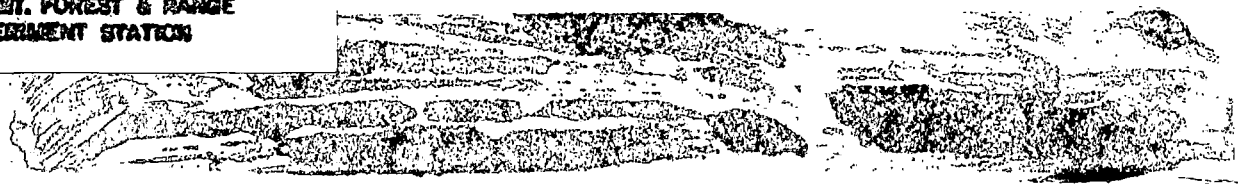
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## INTRODUCTION

Even though forest vegetation of the Rocky Mountains has been extensively studied for many years, the forest vegetation of the Bighorn Mountains of north central Wyoming has been studied much less. The forest vegetation of the Bighorns is very similar to that of the main Cordilleran chain; but the Bighorns are isolated some 350 km east of the main chain of the Rockies and are surrounded by steppe and shrub-steppe vegetation.

The zonation of vegetation on the Bighorns follows the general pattern described by Porter (1962) for Wyoming coniferous forests, with Pinus ponderosa dominating the lowest zone of forests, and Pseudotsuga menziesii, Pinus contorta, Picea engelmannii, and Abies lasiocarpa dominating forests of successively higher elevations.

Town (1899) and Jack (1900) described the vegetation of the Bighorns in a general way; their primary emphasis was on quality, abundance, and distributions of important tree species as well as on grazing potential of the Bighorns. Some discussion of the role of fire was also included. More recent descriptions of the Bighorn forest vegetation include a brief study of the subalpine forests by Rolston (1961) and a study of vegetation in relation to substrate and climate by Despain (1973).

Other vegetation studies in Wyoming having a bearing on the present study include studies of the Jackson Hole area by Reed (1952) and by Oswald (1966), a study of the Wind River Mountains by Reed (1969), a study of the spruce-fir forests of the Medicine Bow Mountains by Oosting and Reed (1952), and a later study of the Medicine Bow Mountains by Wirsing (1973). Forest habitat types of eastern Montana described by Pfister et al. (1974) are also pertinent to the present study, as well as brief descriptions of forest vegetation of the Black Hills by Thilenius (1971,1972).

Objectives of the present study were the following:

- 1) delimit and describe the forest habitat types of the Bighorn Mountains,
- 2) describe the successional patterns of forest vegetation observed in the Bighorns,
- 3) relate topographic and edaphic factors to the habitat types,
- 4) relate Bighorn forest habitat types to those of surrounding areas in Montana, Wyoming, and western South Dakota.

## GEOGRAPHY AND GEOLOGY

Located in north central Wyoming the Bighorn Mountains are bordered on the east by the Powder River basin and on the west by the Bighorn River basin. On the north are the Pryor Mountains and to the southwest are the Owl Creek Mountains. The east and west basin elevations are 900-1200 m and the Bighorn Mountains rise from the plain to a maximum elevation of 4016 m at the summit of Cloud Peak. The mountain range is some 193 km long and 35-50 km wide.

The Bighorns are a relatively simple asymmetric anticline which is quite naturally divided into northern, middle and southern segments. During the formation of this mountain range the northern and southern segments were thrust to the west and the middle segment was thrust to the east. The northern and southern segments form subsummit plateaus of about 2740 m and 2440 m respectively. In the central segment of the mountains the exposed core of precambrian granite forms the highest peaks. The northern and southern segments are overarched by sedimentary rocks of Paleozoic and Mesozoic age. Though some members of the geologic succession of rocks from precambrian to Cenozoic are missing, the succession of sedimentary rocks present have been described (Darton 1906, Bucher et al. 1933, Demorest 1941, Sharp 1948 and others) and are the following: Flathead sandstone of

Cambrian age (82 - 111 m thick), overlying precambrian granites; Gros Ventre shales, 122 - 137 m thick, also of Cambrian age, in which limestone occurs in the upper layers. Next in succession is the Bighorn dolomite of Ordovician age, 92 m thick, Madison limestone, 76 - 336 m thick, deposited during the Mississippian; Amsden formation, 61 - 112 m thick, consisting of shale and sandstone, deposited during the Mississippian and Pennsylvanian; Tensleep sandstone, 9 - 46 m thick, deposited during the Pennsylvanian. Tensleep sandstone is found along the lower parts of the mountains and in some places it also occurs on top of the southern third of the mountains. The Mesozoic age Chugwater formation consists of deposits of red calcareous shale and sandstones which have been eroded and occur primarily at the base of steep slopes; these deposits are red in color and unusually thick, 220 - 365 m (Darton 1906, Demorest 1941). Cenozoic deposits, judged to be Tertiary-aged, are found along the east base of the mountains; some Tertiary gravels also occur on the subsummit plateaus (Sharp 1948).

Some glaciation occurred during the Pleistocene but glaciers were confined to high elevations extending down-slope through valleys. None reached the basal plain.

Geologic parent material has most influence on vegetation before much weathering has altered its distinctive characteristics. With time, as weathering occurs

and vegetation develops, much of the distinctive influence of certain geologic formations on vegetation becomes somewhat masked, if not totally obscured.

## CLIMATIC CHARACTERISTICS

Only one weather station is currently located in the Bighorn Mountains, at Burgess Junction. Until 1930 weather data were collected from at least three additional stations in the Mountains. As a result of regional weather patterns the basal plain west of the Bighorns is considerably drier than that east of the Mountains (Table 1). Precipitation increases upslope on the mountains; at Dome Lake, elevation 2689 m, the average annual precipitation was recorded as 670 mm. Most precipitation occurs during the months April through September though the magnitude of difference in precipitation received during warm and cool months decreases with elevation (Table 1). Except for Dome Lake, all stations for which data were obtained show greatest precipitation during the month of May; at Dome Lake April is the month of greatest precipitation.

Snowfall can occur anytime of the year in the Bighorns (U.S. Dept. Comm. 1960). During the present study measurable snow fell over a broad elevational belt in June, 1973, and twice in August, 1974.

Mean precipitation and temperature data are to be interpreted cautiously as ecosystems respond in a complex manner to environmental variables temperature and precipitation being only two such variables.

Table 1. Mean temperature (T) and precipitation (P) data from selected weather stations in and near the Bighorn Mountains.<sup>a</sup>

Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm	T, P, °C mm
EAST BASAL PLAIN - Buffalo, elev. 1416 m											
-5.4 13.	-4.1 12.	+1.4 20.	+6.1 39.	+11. 60.	+16. 50.	+20. 31.	+19. 28.	+14. 28.	+7.6 19.	+1.4 12.	-3.9 13.
EAST BASAL PLAIN - Sheridan, elev. 1155 m											
-7.3 23.	-5.6 18.	-.39 31.	+6.3 47.	+11. 67.	+16. 49.	+20. 31.	+19. 19.	+13. 37.	+6.9 29.	+.22 19.	-5.3 16.
EAST BASAL PLAIN, NEAR LOWER EDGE OF PINUS PONDEROSA ZONE - Eaton's Ranch, elev. 1402 m											
-3.7 27.	-2.0 27.	+1.7 44.	+7.8 59.	+10. 100	+16. 62.	+20. 32.	+19. 21.	+14. 45.	+8.8 35.	+4.2 20.	-1.0 26.
PSEUDOTSUGA MENZIESII ZONE, EAST SIDE - Hunter's Station, elev. 2256 m											
-7.3 24.	-6.4 23.	-4.3 45.	+7.8 67.	+5.0 85.	+10. 60.	+14. 51.	+13. 41.	+8.5 43.	+3.2 45.	-1.4 21.	-6.4 23.
ABIES LASIOCARPA ZONE - Dome Lake, elev. 2689 m											
-9.4 38.	-9.0 34.	-6.1 64.	-1.6 95.	+2.9 83.	+8.4 63.	+12. 50.	+11. 44.	+6.7 51.	+1.1 61.	-3.9 47.	-8.7 40.
ABIES LASIOCARPA ZONE - Burgess Junction, elev. 2450 m											
-8.9 31.	-7.0 53.	-6.3 41.	-2.3 73.	+3.8 51.	+8.9 65.	+13. 36.	+12. 32.	+6.7 44.	+2.2 39.	-3.6 31.	-8.2 27.
WEST BASAL PLAIN - Hyattville, elev. 1412 m											
-5.1 9.1	-3.2 5.1	+1.7 12.	+7.4 14.	+12. 13.	+18. 16.	+21. 4.1	+20. 9.1	+15. 9.4	+8.4 12.	+2.0 6.9	-4.0 8.9
WEST BASAL PLAIN - Worland, elev. 1238 m											
-11. 9.1	-6.0 6.3	+.67 10.	+7.2 23.	+12. 31.	+18. 29.	+22. 17.	+20. 17.	+14. 25.	+7.3 18.	-.67 7.9	-7.9 5.8
WEST BASAL PLAIN - Basin, elev. 1170 m											
-9.2 11.	-5.7 10.	+1.2 15.	+8.2 19.	+14. 27.	+19. 22.	+23. 12.	+22. 10.	+15. 17.	+8.1 15.	+.22 8.6	-7.9 10.
WEST BASAL PLAIN - Lovell, elev. 1166 m											
-9.6 11.	-5.3 6.3	+.39 7.1	+7.6 15.	+13. 33.	+18. 20.	+21. 16.	+20. 13.	+14. 19.	+7.2 13.	-.22 8.9	-7.8 6.6

<sup>a</sup>U.S. Dept. Agric. 1934; U.S. Dept. Comm. 1960.

## SYNECOLOGIC TERMS AND CONCEPTS PERTINENT TO THIS STUDY

Because the terminology in ecology is not uniformly used, or understood, the following definitions and concepts are presented as they will be used throughout this paper. Unless specifically stated otherwise, all terms follow the usage proposed by Daubenmire (1968) and Daubenmire and Daubenmire (1968). Climax vegetation is that which has attained a steady state with its environment, and species of climax vegetation successfully maintain their population sizes. Seral communities are comprised of those stands of vegetation in which a steady state has not been attained and current populations of some species are being replaced by other species. All stands of climax vegetation which are very much alike, having the same overstory dominants and understory dominants, are grouped into a single plant association. Plant associations having the same overstory dominants are grouped into series.

Much of the study region has been disturbed by fire, logging, and grazing all of which have been factors of the environment for many years (Jack 1900). Because of the disturbance, much of the land area does not currently support climax vegetation. However, that land area which does support, or has the potential of supporting a single plant association is called a habitat type. For example,

the Pseudotsuga menziesii - Physocarpus monogynus habitat type is all the land area of the study region currently supporting the plant association by the same name plus all the land area in the same region which will come to support this plant association in the absence of disturbance. It is quite possible that much of the land of a given habitat type will never attain climax status. Nevertheless it is still important to consider land units in terms of their potentialities (i.e. habitat types). With habitat types one can relate tree productivity and disease susceptibility (Daubenmire 1961); and microclimate and soils are often closely related to habitat types. From the standpoint of basic as well as applied ecology in dealing with forest resources, the habitat type concept offers a useful approach.

As the habitat type is the basic unit in classifying natural vegetation, the series is the next higher category of classification in which habitat types having the same dominant species are grouped together. In the Bighorns Pinus ponderosa is the dominant species of five habitat types all of which are grouped into the Pinus ponderosa series. The series is more than an artificial grouping of vegetation types using the climax dominant as the convenient thread of continuity. There is ecologic basis for grouping vegetation types into series as defined here.

For example, Pinus ponderosa occupies habitats which are warmer and drier than habitats on which Pseudotsuga menziesii is the climax dominant. Additionally, continuing higher into the mountains, Pinus contorta, Picea engelmannii, and Abies lasiocarpa successively become the successful competing dominant species. Self-perpetuating populations of these trees are doubtlessly related to the macroclimates of the regions in which they dominate, as they have been reported to be in eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968). In the absence of concrete data for the Bighorns, we can assume that these dominant trees are more related to the macroclimate than is undergrowth vegetation which is more related to microclimate and soils. A series then represents a physiognomic form which can be related to other stands of the same series both in the Bighorns and in nearby forests of Wyoming, southern Montana, and western South Dakota. Habitat types within a given series are differentiated on the basis of undergrowth vegetation which, as indicated, reflects variation in microclimate and soils to a greater extent than do the dominant trees.

## METHODS

During July and August, 1972, I traveled extensively throughout the Bighorn Mountains to gain familiarity with possible forest habitat types as well as collect plant species throughout the various habitat types. A list of possible study sites was noted along with brief descriptions of the sites.

During the field seasons of 1973 and 1974, centering on the period of 1 June to 25 August, I sampled 93 stands of forest vegetation. Most of these stands were old and near-climax or in late seral stages of succession. Within each stand to be studied intensively I laid out a 15 x 25 m plot using 4 permanent stakes at the corners and perimeter delimited by string. The exact location of the plot and the permanent corner stakes facilitated re-locating the plots later, if required. The plots were always laid out with the long dimension parallel to the contour of the slope and always well within the stand to avoid ecotones, trails, and other obvious forms of disturbance. The plots also always included the largest trees in the stand so that the vegetation and soils would be representative of the most mature part of each stand. Each 15 x 25 m plot was then subdivided into three 5 x 25 m macroplots, again using heavy string to delimit the macroplots.

Within the 15 x 25 m plot (375 m<sup>2</sup>) I recorded every tree taller than 1 m in decimeter diameter classes as determined at breast height. To later calculate tree basal areas the midpoints of the diameter classes were used (Table A, App. I). Because the plots were purposely placed around the largest trees in each stand, except where the largest trees were near the edge of the stand, the basal area calculations are necessarily larger than expected for average conditions throughout the forests of the Bighorns. However, the technique used was consistent throughout so the results will also be consistent throughout. Additionally, trends in basal area are evident from the data collected and any correction to alter data for average conditions could be made if necessary. Trees less than 1 m tall were counted in two 1 x 25 m transects along the inner sides of the central macroplot. Tree population structure data are presented in Table A, App. I.

Coverage of undergrowth shrub and herbaceous species was recorded in fifty 2 x 5 dm microplots placed systematically along the inner sides of the central macroplot. Canopy coverage of each species was estimated within each microplot using a technique modified from Daubenmire (1959) as follows:

Coverage Class	Actual Coverage (range)	Coverage Midpoint
1	1 - 5 %	2.5%
2	6 - 25%	15.5%
3	26 - 50%	38%
4	51 - 75%	63%
5	76 - 95%	85.5%
6	96 - 100%	98%

In the field only the number 1, 2, 3, 4, 5, or 6 was recorded for each species in each microplot (moss species and lichen species were lumped) representing the coverage ranges given above. To calculate actual average cover for each species in the 50 microplots the midpoints of the coverage ranges were used, also shown above. Frequency was determined for each species in each stand, and both coverage and frequency data for undergrowth species for all stands are recorded in Tables B-F, App. I. A list was made of those species not occurring in the 50 microplots but occurring within the 375 m<sup>2</sup> area; this insured a reasonably complete floristic list for each stand studied.

Finally, 25 soil cores representing the upper dm of the mineral soil were collected from the central macroplot in each stand. These samples were air-dried in the field then composited for laboratory analysis. Soil passing through a 2 mm sieve was used to determine texture using

a modified Bouyoucos method (Moodie, Smith, and Hausenbuiler 1963). Other soils characteristics determined for each stand sample were pH using a glass electrode on the saturated soil paste, cation exchange capacity on the ammonium acetate extract; exchangeable Ca, Mg, K, and Na were also determined from the ammonium acetate extract. Kjelhahl N and P by the Bray technique were also determined (Pratt and Chapman 1961).

Representative soil profiles were described by Mr. Gary Kellogg, Soil Scientist, U. S. Forest Service.

Voucher specimens of plant species collected during this study are on file at the Rocky Mountain Herbarium, University of Wyoming.

## THE HABITAT TYPES

Pinus ponderosa Series

The Pinus ponderosa series includes those habitat types in which Pinus ponderosa is the sole dominant. All habitat types in this series not only have a common dominant species but occur within the range of environmental conditions permitting Pinus ponderosa to maintain its population as a climax species. The habitat types which occur within this range of environmental conditions, i.e. within this series, are differentiated on the basis of undergrowth vegetation. This statement holds true for all the series as described below. The dominant tree species remains the same throughout each series but the habitat types within each series are delimited on the basis of undergrowth vegetation.

Following disturbance in the Bighorns Pinus ponderosa reinvades its former habitats and has competition from no other tree species except for an occasional Populus tremuloides which is not abundant and offers little competition. Along the eastern flank of the Bighorns there is a well-developed belt of Pinus ponderosa-dominated forest along the dry and lower limits to which coniferous forests extend; and at the dry limits of the P. ponderosa forests they are confined to coarse-textured substrates. Along the western flanks of the Bighorns there is a narrow belt

of climax Pinus ponderosa forest in the southwestern segment of the mountains. Most of the Pinus ponderosa along the western side of the mountains is seral to Pseudotsuga menziesii.

Pinus ponderosa - Agropyron spicatum habitat type.

Only one stand of P. ponderosa - A. spicatum habitat type was studied though others were observed. This habitat type occupies the most xeric habitats on shallow soils along the eastern flanks of the mountains. The undergrowth is conspicuously dominated by graminoids (Table B, App I.), with some forbs present. The widely spaced trees of this habitat type permit considerable radiation to reach ground surface adding to the xeric nature of the habitat and permitting luxuriant growth of the heliophytic undergrowth species. Tree reproduction in this habitat is apparently circumstantial, resulting in patches of even-aged trees. In the single stand sampled only four diameter classes were represented (Table A, App. I). This habitat type is almost entirely below the limits of the National Forest boundary.

Pinus ponderosa - Festuca idahoensis habitat type.

Many of the same undergrowth species are shared by the P. ponderosa - A. spicatum and P. ponderosa - F. idahoensis habitat types. The latter however occupies more mesic habitats and is characterized by considerably more

Festuca idahoensis and much less A. spicatum. This habitat type is not necessarily confined to slopes of 90° to 270° aspect as it apparently is in Montana (Pfister et al. 1974). In the Bighorns this habitat type occurs on slopes adjacent the P. ponderosa - Spiraea betulifolia habitat type and the P. ponderosa - Physocarpus monogynus habitat type. Though tree reproduction is more consistent with time in this habitat type than in the P. ponderosa - A. spicatum habitat type, it is still somewhat episodic and probably related to fire history.

Where climax P. ponderosa stands occur there is no evidence of succession toward a Pseudotsuga menziesii forest. It is apparent that much of the discussion of Pinus ponderosa forests by Despain (1973) is based on stands in which succession is progressing toward a Pseudotsuga menziesii-dominated forest.

Pinus ponderosa - Spiraea betulifolia habitat type. Farther into the mountains, or on habitats more mesic than those supporting either of the above habitat types, and always along the eastern slopes of the mountains, the undergrowth loses much of its xerophytic character and much of the grass cover and becomes a mixture of grasses and perennial forbs and low growing shrubs in which a few species are dominant, including Spiraea betulifolia and Symphoricarpos albus. In the Bighorns Spiraea is the

more constant species of the two. Conspicuous by their absence are Rhus trilobata, Agropyron spicatum, Aristida longiseta, Artemisia frigida, and Astragalus succulentus. Grasses which are present in this habitat type and shared with both more xerophytic and mesophytic habitat types include Festuca idahoensis, Hesperochloa kingii, and Poa palustris. Poa interior occurs in this habitat type but is more common in more mesophytic habitat types.

Habitat types similar to the P. ponderosa - S. betulifolia habitat type of the Bighorns occur rather widely. Thilenius (1971) gave a very brief description of a P. ponderosa - Symphoricarpos albus habitat type in the Black Hills. Later Thilenius (1972) described seven "habitat units" in the Black Hills in which Pinus ponderosa was a dominant and Symphoricarpos albus was a major undergrowth species. The habitat units described by Thilenius were delimited by a cluster analysis technique which is described in detail elsewhere (Sokal and Sneath 1963). This technique has certain shortcomings, however, which can result in highly artificial groupings of stands. Stands which have a high calculated coefficient of similarity (Oosting 1956) may not be grouped together at a level suggested by the initial similarity coefficient. Indeed, these same two stands may not even end up in the same "cluster." On the other hand stands which initially

have a relatively low similarity coefficient may become grouped at a higher level than initial coefficients would warrant. A review of clustering techniques is given by Williams and Dale (1965). What seems apparent is that the more times the initial data are manipulated (e.g. recalculating a matrix of similarity coefficients after each pair of high coefficients has been grouped) the less the probability that the final hierarchy of stands of vegetation is a realistic picture of the relatedness of the stands of vegetation. Pfister et al. (1974) described a P. ponderosa - Symphoricarpos albus habitat type in Montana which exhibits several floristic and ecologic similarities to the P. ponderosa - Spiraea betulifolia habitat type in the Bighorns. In Montana the xerophytic Agropyron spicatum and the mesophytic Physocarpus malvaceous both occur in the P. ponderosa - Symphoricarpos albus habitat type. In the Bighorns neither A. spicatum nor Physocarpus monogynus, a close taxonomic relative of P. malvaceous, occurs in the P. ponderosa - Spiraea betulifolia habitat type. In northern Idaho and eastern Washington the P. ponderosa - Symphoricarpos albus habitat type is present as a topographic or edaphic climax in the dry steppe region, as the climatic climax in the mountain foot hills, and again as a topographic climax farther into the mountains (Daubenmire and Daubenmire 1968).

A description of the soil profile of site 63, representative of the P. ponderosa - Spiraea betulifolia habitat type follows:

This soil is a member of the loamy-skeletal, mixed family of Mollic Eutroboralfs.

Pedon: (colors are for moist soil unless stated otherwise)

- 01 4-2 cm.--Needles, cones, and twigs
- 02 2-0 cm.--Decomposed organic matter
- A11 0-4 cm.--Very dark grayish brown (10YR 3/2); weak fine crumb structure; soft, very friable, nonsticky, nonplastic; many roots; medium acid (pH 5.68 in 0.01 M  $\text{CaCl}_2$ ); abrupt wavy boundary.
- A12 4-20 cm.--Very dark grayish brown (10YR 3/2); weak medium subangular blocky structure; slightly hard, friable, slightly sticky, slightly plastic; many roots; medium acid (pH 5.92 in 0.01 M  $\text{CaCl}_2$ ); abrupt wavy boundary.
- A2 20-36 cm.--Light yellowish brown (10YR 6/4); massive; slightly hard, firm, nonsticky, nonplastic; 40 percent granitic gravel and stones; few roots; neutral (pH 6.80 in 0.01 M  $\text{CaCl}_2$ ).
- B2t 36-54 cm.--Yellowish brown (10YR 5/4); gravelly sandy clay loam; weak medium angular blocky structure that parts to weak fine angular blocky; hard, firm, sticky, plastic; clay films on ped faces; 50 percent granitic gravel and stones; very few roots; neutral (pH 6.71 in 0.01 M  $\text{CaCl}_2$ ); clear wavy boundary.
- C 54-67 cm.--Yellowish brown (10YR 5/4); gravelly sandy clay loam; massive; hard, firm, slightly sticky, slightly plastic; 50 percent granitic gravel and stones; very few roots; slightly acid (pH 6.12 in 0.01 M  $\text{CaCl}_2$ ).

Pinus ponderosa - Juniperus communis habitat type.

This habitat type is limited in extent to a portion of the southeastern segment of the Bighorns where the undergrowth is floristically poor (Table B, App. I). Only 15 undergrowth species were encountered in the one stand studied and very few additional species were observed in reconnaissance stands of this habitat type. Juniperus communis is by far the dominant member of the undergrowth. The xeric habitats on which this habitat type occurs is a limiting factor in the development of the undergrowth though various size classes of Pinus ponderosa are well-represented indicating successful seedling establishment of the overstory dominant. The largest tree in this stand had 240 xylem layers at breast height.

This, or a similar habitat type, is not reported for Montana (Pfister et al. 1974) or eastern Washington and northern Idaho (Daubenmire and Daubenmire 1968). Thilenius (1971) did report a similar habitat type in the Black Hills in which the undergrowth vegetation was dominated by both Juniperus communis and Mahonia repens which judging from the brief description provided, may be similar to the undergrowth of the Pseudotsuga menziesii - Mahonia repens habitat type of the Bighorns.

Pinus ponderosa - Physocarpus monogynus habitat type.

The most favorable sites on which Pinus ponderosa attains

climax status have an undergrowth dominated by Physocarpus monogynus and are characterized by a relatively rich assortment of accompanying species (Table B, App I). The four stands of this habitat type studied averaged 27 undergrowth species per stand. There is considerable floristic similarity between this habitat type and the P. ponderosa - Spiraea betulifolia habitat type with 52% of the species shared by these two habitat types. Of the four stands of this habitat type which were sampled, stands 8 and 9 are younger and apparently were burned during this century; the largest trees of these stands had 57 and 74 xylem layers (at breast height) respectively. In stands 6 and 79 the largest trees had 209 and 248 rings respectively. Heights of the trees were not determined in any of the habitat types so site indexes can not be estimated.

In addition to Physocarpus monogynus, Acer glabrum and Amelanchier alnifolia occurred in this habitat type and not in other P. ponderosa-dominated vegetation. Among low shrubs, graminoids, and other herbaceous undergrowth attaining a coverage of at least 0.5% Carex xerantica, Stipa columbiana, Aster conspicuus, Epilobium angustifolium and Fragaria virginiana occurred in this habitat type and not in other P. ponderosa-dominated habitat types. Arnica cordifolia was present in stands 8 and 9, the

younger of the four stands studied, and in stand 8 had a coverage of 21% and a frequency of 88%. This species was only rarely encountered in the more xerophytic habitat types dominated by P. ponderosa. All stands of this habitat type occur along the east side of the mountains. All stands of this habitat type face NW to NE and range in elevation from 1400 - 1800 m. Lower in elevation, or on more xeric habitats the undergrowth loses the mesophytic components of the Physocarpus union, picks up more xerophytic elements and the habitat type becomes recognizable as the P. ponderosa - Spiraea betulifolia habitat type or the P. ponderosa - Festuca idahoensis habitat type. There is no counterpart to this habitat type in the Black Hills to the east (Thilenius 1971), or in southeastern Montana to the north (Pfister et al. 1974). In Montana, however, Pfister et al. (1974) describe a P. ponderosa - Prunus virginiana habitat type which shares with the P. ponderosa - Physocarpus monogynus habitat type of the Bighorns such species as P. virginiana, Amelanchier alnifolia, Symphoricarpos albus, Galium boreale, Cystopteris fragilis, Arnica cordifolia, and Mahonia repens. But the important diagnostic species, Physocarpus monogynus, does not occur in P. ponderosa-dominated vegetation of southeastern Montana. Like the P. ponderosa - Prunus virginiana habitat type of Montana, the P. ponderosa - Physocarpus monogynus

habitat type of the Bighorns occurs on slopes receiving little or no direct solar radiation, though the latter habitat type does occur at higher elevations.

It is an interesting fact that an apparently more closely related habitat type is the P. ponderosa - Physocarpus malvaceus habitat type in eastern Washington and northern Idaho described by Daubenmire and Daubenmire (1968). Their description of the habitat type is one of a P. ponderosa union superimposed over a Physocarpus malvaceus union which in turn is superimposed over the Symphoricarpos albus union. In the Bighorns, however, Physocarpus monogynus never attains the stature or density exhibited by P. malvaceus of the northern Rockies as a result of which the Spiraea betulifolia union beneath P. monogynus is much less shaded and attenuated than the corresponding low shrub union of eastern Washington and northern Idaho. Though experimental data are lacking, it is possible that without the mesic north-facing slopes on which this habitat type occurs in the Bighorns, it would be absent altogether. Additionally, this habitat type is not consistently adjacent the P. ponderosa - Spiraea betulifolia habitat type. Rather, in the Bighorns, it also occurs adjacent the P. ponderosa - Festuca idahoensis habitat type, the abruptness of change in available soil moisture seemingly being the controlling factor.

In the Bighorns five habitat types are recognized in which Pinus ponderosa is the climax dominant. In all, Pinus ponderosa is the only tree species not withstanding an occasional P. tremuloides and the observation by Despain (1973) that "Pseudotsuga menziesii and Pinus flexilis are usually represented in those forests."

This observation and his choice of sampling stands has influenced his conclusions about P. ponderosa forests in the Bighorns (Despain 1971, 1973). Despain (1973) also described Pinus ponderosa dominated forests in the Bighorns as "open" ranging in age from 60 to 100 years and with basal areas ranging from 8.8 to 24.8 m<sup>2</sup>/ha.

In the present study P. ponderosa in these five habitat types showed a range of 57 to 280 xylem layers at breast height with a median of 97 layers. Additionally, in my sampled stands, tree basal areas ranged from 16.2 to 60.2 m<sup>2</sup>/ha, with a median of 33.5 m<sup>2</sup>/ha, considerably greater than that reported by Despain (1973). Even considering the environmental factors of fire and cutting of timber, there still remain isolated stands of old Pinus ponderosa which have developed to climax stage. From these old stands plus others dominated by P. ponderosa, one can determine the potentialities and successional direction of the five habitat types described. The full areal extent of these habitat types is very difficult to deter-

mine, particularly in view of the widespread and common fires during the 1800's and early 1900's.

Pinus ponderosa-dominated vegetation along the west side of the mountains is characteristically open with trees widely spaced and an undergrowth of Juniperus osteosperma, Artemisia tridentata, Juniperus communis, Hesperochloa kingii and numerous herbaceous heliophytes. Because of the limited extent of this vegetation, as well as its open character, stands of this vegetation were not sampled.

Pseudotsuga menziesii Series

Pinus ponderosa maintains climax status on xeric habitats at low elevations where no other conifer can successfully compete with the pine. However, higher on the slopes, or farther into the mountains, where the moisture balance is considerably more favorable,

Pseudotsuga menziesii replaces P. ponderosa as the climax dominant. In the Bighorns P. menziesii is a climax dominant at intermediate elevations of 1878 - 2609 m and frequently on limestone- or dolomite-derived soils. On these habitats Pinus ponderosa, Pinus flexilis, Pinus contorta, and occasionally Populus tremuloides may be present in any combination as seral species. The affinity of Pseudotsuga for sedimentary substrates with high calcium contents may result from the high calcium requirement of the species, the coincidental overlap of suitable substrate with temperature-moisture ranges suitable to meet the requirements of the species, or more probably, a combination of these plus other factors. It has been demonstrated repeatedly that Pseudotsuga is climax on habitats having more favorable moisture balance than those on which Pinus ponderosa is climax. Additionally, Pseudotsuga foliage sampled in the northern Rockies exhibits higher amounts of calcium than foliage of P. ponderosa, P. contorta, Picea engelmannii, or Abies lasiocarpa

(Daubenmire 1953). In the Bighorns the upper dm of mineral soil from Pseudotsuga habitats contains an average of 35.6 meq calcium / 100 g soil (Table G, App. II).

Basal areas of Pseudotsuga in this study ranged from 13.2 to 95.1 m<sup>2</sup>/ha. This compares to a basal area range of 8.5 to 64.4 m<sup>2</sup>/ha reported by Despain (1973). The largest tree I observed in the Bighorns was a Pseudotsuga measuring 16.6 dm dbh, located on the west side of the mountains.

The number of xylem layers of Pseudotsuga (at breast height) ranged from 60 to 247 with a median value of 129. Except for a limited number of very large Pseudotsugas growing in isolated clumps, the age of this species never exceeded 250 years in any of the stands sampled. Pseudotsuga is climax on both the east and west sides of the Bighorns. On the west side it commonly forms the lowest zone of coniferous forest; on the east side it occupies a position along the moisture-temperature gradient intermediate between Pinus ponderosa- and Pinus contorta-dominated forests. The status of Pseudotsuga along the lower elevations of the western slopes varies from climax to seral. In certain habitats Picea engelmannii is climax right to the lowest edge of the coniferous forests.

Juniperus communis phase, Pseudotsuga menziesii-Mahonia repens habitat type. The most xeric habitats on which Pseudotsuga menziesii maintains climax status are on the southeastern flank and along the low summits of the southern ridges of the Bighorns. In these habitats Pinus ponderosa, Pinus flexilis, and to some extent Pinus contorta and Populus tremuloides are present as seral species. The undergrowth of these stands is characterized by Juniperus communis conspicuously present among other members of the Mahonia repens union including Ribes lacustre, Symphoricarpos oreophilus, Rosa acicularis, Hesperochloa kingii, Poa nervosa, Arnica cordifolia and Galium boreale. In Montana Pfister et al. (1974) recognized a Pseudotsuga menziesii - Juniperus communis habitat type. With additional study the Juniperus phase of the Pseudotsuga - Mahonia habitat type in the Bighorns may warrant recognition as a separate habitat type.

Pseudotsuga menziesii - Mahonia repens habitat type. This habitat type is widespread in the Bighorns and the self-reproducing population of Pseudotsuga along with diagnostic members of the Mahonia repens union serve to identify the type. The undergrowth is a mixture of low-growing shrubs and herbs; important members include Mahonia repens, Ribes lacustre, Juniperus communis, Hesperochloa kingii, Poa nervosa, Arnica cordifolia, Senecio streptanthifolius,

and Symphoricarpos oreophilus. This habitat type is most common on sedimentary substrates at elevations ranging from 2158 to 2609 m, and on slopes facing 65° all the way to 274° (Table C, App. I). The soils of this habitat type are all silt loams or loams, have pH values of 6.4 to 7.7 and all have cation exchange capacities in excess of 21.7 meq/100 g (Table G, App. II). Reed (1969) reported a similar habitat type occurs in the Wind River Mountains of Wyoming, the Pseudotsuga menziesii - Symphoricarpos oreophilus habitat type in which Symphoricarpos dominates the undergrowth though Mahonia repens is part of the same union. Other important undergrowth species shared by these two habitat types include Hesperochloa kingii, Poa nervosa, and Arnica cordifolia. The Pseudotsuga menziesii - Spiraea betulifolia and P. menziesii - Arnica cordifolia habitat types of Montana (Pfister et al. 1974) are also similar to the P. menziesii - Mahonia repens habitat type of the Bighorns. In fact, in the Bighorns, Arnica cordifolia has an average coverage of 12% and a constancy of 7/8 in the stands of this habitat type. These values compare to 8% and 6/11, and 26% and 9/13 in the P. menziesii - Spiraea betulifolia and P. Menziesii - Arnica cordifolia habitat types respectively (Pfister et al. 1974). Thus Arnica cordifolia actually exhibits higher constancy in the P. menziesii - Mahonia repens habitat type of the Bighorns than in the P. menziesii - Arnica cordifolia habitat type

of Montana, though other indicator species may have higher constancy in this vegetation type of Montana. In their P. menziesii - Spiraea betulifolia habitat type Pfister et al. (1974) stated that "the habitat type is apparently too dry for the normal indicators such as Calamagrostis rubescens, Carex geyeri, and Symphoricarpos albus to be well represented." Unfortunately, to state that certain indicators are "normal" implies that others are abnormal, or perhaps that certain habitat types are more or less normal than others. It is more realistic to understand that certain species are good indicators for certain habitat types, and terms such as "normal indicators" should be avoided.

Biotic succession following disturbance in a P. menziesii - Mahonia repens habitat type in the Bighorns involves not only reestablishment of Pseudotsuga but also invasion of the sites by P. ponderosa, P. flexilis, P. contorta, and occasionally Populus tremuloides. The course of succession in the P. menziesii - Mahonia repens habitat type is clearly indicated along both sides of the Tensleep Canyon along the west side of the Bighorns. Much of the substrate here is glacial moraine, and sedimentary material of shales and sandstones. Succession along the slopes of this canyon is characterized by invasion of the Artemisia tridentata shrub-steppe communities by Pinus flexilis and Pseudotsuga menziesii directly,

or establishment of Juniperus communis which then provides the suitable microhabitat in which Pseudotsuga becomes established. Many seedlings of Pseudotsuga occur directly under Artemisia shrubs where shade and greater moisture provide suitable habitat for the trees to become established. Where tree seedlings become established under a Juniperus shrub the latter remains a part of the developing community for many years. In fact, in mature stands of this habitat type, dead remains of Juniperus communis are often observed around the bases of the oldest trees of the community. Members of the Mahonia union also occur throughout the Artemisia shrub-steppe particularly within 100 m or less of the edge of a developing Pseudotsuga stand. It is possible that biotic succession observed in Tensleep Canyon is primary, the tree vegetation only now beginning to invade the shrub-steppe. In northwestern Yellowstone Park, Wyoming, Patten (1969) described a similar phenomenon in which Pinus contorta is invading Artemisia tridentata shrub-steppe. One hypothesis for this successional trend, which might also apply to the Bighorns, is a gradual climatic change resulting in cooler temperatures and greater soil moisture making microclimatic conditions more suitable for the invasion of the shrub-steppe by tree species. In the Bighorns, along Tensleep Canyon in particular, the increase in Pseudotsuga appears to be an

example of primary succession rather than reestablishment following disturbance.

Pseudotsuga menziesii - Physocarpus monogynus habitat type. This habitat type occurs on both the east and west sides of the mountains on slopes facing northwest to northeast. The overstory is dominated by P. menziesii though P. ponderosa and P. flexilis are both common seral species. The undergrowth, the Physocarpus monogynus union, is dominated by P. monogynus, with Symphoricarpos oreophilus, Spiraea betulifolia, Rosa acicularis, and Mahonia repens making up the complement of important undergrowth shrubs. Pfister et al. (1974) do not report a P. menziesii - Physocarpus malvaceous habitat type in Montana nor is there a comparable habitat type in the Wind River range (Reed 1969). However, Daubenmire and Daubenmire (1968) describe a P. menziesii - Physocarpus malvaceous habitat type in eastern Washington and northern Idaho, but it is similar to the P. menziesii - P. monogynus habitat type of the Bighorns in only a general way. Both these habitat types exhibit fewer species and less undergrowth coverage than the Pinus ponderosa - Physocarpus malvaceous and P. ponderosa - P. monogynus habitat types of the northern Rockies and in the Bighorns respectively.

The P. menziesii - P. monogynus habitat type of the west side of the Bighorns exhibits a more xerophytic

character than that of the east side. Such species as Balsamorhiza sagittata, Arnica cordifolia, Anemone multifida, Clematis tenuiloba, and Lomatium dissectum, all part of the habitat type on the eastern side of the mountains, are not a part of this habitat type on the western side of the mountains. The total number of species in this habitat type is also considerably less on the west side. I did not separate stands of the vegetation type on the west side of the mountains from those on the east side, but studies of soil moisture regimes and Pseudotsuga and Pinus ponderosa growth rates might be warranted and prove interesting in a comparison of the xeric west side with the more mesic east side.

A soil profile description of site 20, representative of this habitat type, follows:

This soil is a member of the loamy-skeletal, mixed family of typic Cryochrepts.

Pedon: (Colors are for moist soil unless otherwise noted.)

- 01            7-6 cm.--Needles, cones, and twigs
- 02            6-0 cm.--Decomposed organic matter
- A1            0-7 cm.-- Brown (7.5YR 5/4) silt loam; massive, slightly hard, friable, slightly sticky, plastic; 10 percent limestone gravel and cobbles; common roots; slightly acid (pH 6.12 in 0.01 M CaCl<sub>2</sub>); abrupt wavy boundary.

- B2 7-30 cm.--Strong brown (7.5&R 5/6) very gravelly silty clay loam; moderate fine angular blocky structure that parts to moderate very fine angular blocky; slightly hard, friable, sticky, plastic; 75 percent limestone gravel and cobbles; common roots; neutral (pH 7.28 in 0.01 M CaCl<sub>2</sub>); clear wavy boundary.
- B3 30-48 cm.--Brown (7.5YR 5/4, dry) very gravelly silt loam; moderate fine angular blocky structure that parts to moderate very fine angular blocky; slightly hard, friable, slightly sticky, plastic; 75 percent limestone gravel and cobbles; common roots; mildly alkaline (pH 7.56 in 0.01 M CaCl<sub>2</sub>); clear wavy boundary.
- Clca 48-57 cm.--Pinkish gray (7.5YR 6/2, dry) very gravelly silt loam; massive; soft, very friable, slightly sticky, slightly plastic; 75 percent limestone gravel and cobbles; common roots; violently effervescent; abrupt wavy boundary.
- C2ca 57-67 cm.--Pink (7.5YR 8/4, dry) very gravelly silt loam; massive; slightly hard, very friable, non-sticky, non-plastic; 75 percent limestone volume gravel and cobbles; common roots; violently effervescent.

A Juniperus osteosperma phase of this habitat type might be recognized. Along the west slopes of the Big-horns, J. osteosperma is a part of the undergrowth of certain stands representative of the P. menziesii - Mahonia repens habitat type. This possible phase of the habitat type was examined only in reconnaissance plots where the Mahonia union is essentially intact and the Juniperus is an

addition having extended upslope from its position as a dominant with Artemisia tridentata in the lower elevation shrub-steppe. A closer examination of stands having conspicuous amounts of J. osteosperma, particularly with regard to edaphic factors, tree growth rates, and disease susceptibility might prove rewarding and warrant separation of these stands in the forest classification scheme.

Populus tremuloides series

In the Bighorn Mountains Populus tremuloides is not a major tree species. It forms small stands within the elevational ranges where Pinus ponderosa and Pseudotsuga menziesii are climax species. Usually, Populus tremuloides occurs in somewhat more mesic habitats and on deeper soils; and frequently it occurs between coniferous forest and a park or unforested opening where herbaceous species dominate. I found no stands of Populus tremuloides in the Bighorns that were ungrazed (cf. Table D, App. I); in fact most stands are heavily grazed and cattle frequently congregate in these stands during the heat of the day through much of the growing season.

In size Populus never exceeded the 2 - 3 dm dbh class and basal area ranged from 22.4 to 48.5 m<sup>2</sup>/ha in the stands sampled. Most of the seedling size individuals were root sprouts.

In the Rocky Mountains generally, Populus tremuloides is a much more important tree south and west of the Bighorns (Baker 1925).

Populus tremuloides - Lupinus argenteus habitat type.  
Because of the relative unimportance of this habitat type in the Bighorns, only four stands were analyzed. All are located between 2140 and 2365 m elevation. Two stands, numbers 61 and 17, are in valleys close to streams.

The undergrowth consists of a relatively rich mixture of graminoids and forbs; shrubs are much less important. Lupinus argenteus, Poa nervosa, Hesperochloa kingii, Festuca idahoensis, and Carex scopulorum are characteristic undergrowth species. Because of disturbance, Taraxacum officinale is the most abundant undergrowth species having an average coverage of 20% (Table D, App. I). Other species favored by the disturbed nature of these stands are Phleum pratense and Dactylis glomerata. In all, the undergrowth averaged 25 species per stand and the total undergrowth coverage ranged from 64 to 102%. These figures contrast rather significantly to those reported by Reed (1969) for the Wind River Mountains where Populus tremuloides is a more important species. Reed (1969) found 32 species per stand and an undergrowth coverage of 65 to 349%; additionally, he reported a well-developed shrub layer in P. tremuloides stands.

Soils were analyzed for only two of the four stands of Populus-dominated vegetation. Values determined for soils characteristics are quite in line with those of several other habitat types in the Bighorns.

As noted earlier Populus tremuloides is a more important tree in the central and southwestern Rocky Mountains. In the northern Rockies (Daubenmire and Daubenmire 1968) and over the extent of Montana (Pfister et al. 1974) there are no habitat types dominated by Populus tremuloides.

Pinus contorta Series

The ecologic status of Pinus contorta in the Rocky Mountains has long interested foresters and ecologists. In nearly every report dealing with the ecologic status of this species, mention is made of the fact that it is commonly associated with burned areas, frequently is seral to such species as Pseudotsuga menziesii, Picea engelmannii, Abies lasiocarpa, and that it usually forms dense even-aged stands. Clements (1910) in describing the life history of lodgepole burn forests in Colorado concluded that "without fires lodgepole forests would ultimately be replaced by a mixture of Engelmann spruce and alpine fir, or a forest of Douglas fir ..." Mason (1915) also suggested that in the absence of fire lodgepole pine would be replaced by Engelmann spruce and alpine fir at upper altitudes and by Douglas fir at lower altitudes. However, Mason (1915) also suggested that the middle of the elevational range of the species would probably remain a permanent lodgepole pine community. This idea was further elaborated on by Moir (1969) who described a lodgepole pine zone in the Colorado Front Range; he contended that within the intermediate position of its elevational range this species is not being replaced by Douglas fir, Engelmann spruce, or subalpine fir,

and that under present climatic conditions the lodgepole pine was probably a self-reproducing species in these stands.

In the Bighorn Mountains Pinus contorta is the most abundant forest tree, and its abundance has been attributed to widespread occurrence of repeated fires (Jack 1900, Town 1899). Though it is common for P. contorta to occur in even-aged stands, usually resulting from establishment of the species following fire, this tree can also occur in uneven-aged stands (Alexander 1974) and in some areas of the Bighorns it exhibits the characteristics of a self-reproducing population (Table A, App. I). The presence or absence of serotinous cones influences to a considerable degree the presence of several age classes in the population. Lotan (1967) studied cone serotiny in P. contorta in Montana and found that both serotinous and nonserotinous cones were present, but in different proportions in different stands. In the Bighorns cone serotiny has not been studied systematically, but casual observation indicates both serotinous and nonserotinous individuals do occur. The presence of several age classes in P. contorta stands is also influenced by substrate characteristics; Despain (1973) pointed out that P. contorta forests are most predominate on granitic substrates, an observation

substantiated by the present study. The substrate plus the presence or absence of serotinous cones influence the reproductive patterns of P. contorta in the Bighorns.

P. contorta forests are most abundant in the central third of the Bighorns where exposed granitic substrates are most common. Of the 16 stands of P. contorta-dominated vegetation sampled none had a soil pH in excess of 5.7; the lowest value was 5.0. The average cation exchange capacity was 11.9 meq/100 g (range of 5.10 to 25.6) and average exchangeable calcium was 6.65 meq/100 g (range of 4.33 to 15.0). Other edaphic characteristics of P. contorta stands are given in Table G, App. II. P. contorta vegetation occurs from 2300 m to 2700 m, but as a seral species this tree occurs from 2000 m all the way to upper timberline. It is an important seral species in all Picea engelmannii- and Abies lasiocarpa-dominated forests of the Bighorns. Of all the trees in the Bighorns Pinus contorta exhibits the greatest range of densities. Despain (1973) reported stands having 12,000 stems/ha with a mean diameter of about 6 cm to stands having 600 stems/ha and a mean diameter of about 20 cm dbh. In the present study basal areas for P. contorta ranged from 18.1 m<sup>2</sup>/ha to 55.2 m<sup>2</sup>/ha which compares to a range of 20.0 m<sup>2</sup>/ha to

59.0 m<sup>2</sup>/ha reported by Despain (1973). Xylem layer counts for the largest trees in the stands sampled ranged from 62 to 245 (at breast height) with a median of 149.

Descriptions of P. contorta habitat types which follow indicate my preference of considering this species as climax over part of its range in the Bighorns. Generally, the abundance and areal extent of P. contorta can be attributed to widespread and repeated burning. Throughout much of its range P. contorta is very obviously a seral species to Pseudotsuga menziesii at lower elevations or on more xeric habitats and to Picea engelmannii and/or Abies lasiocarpa at higher elevations or on more mesic habitats. But there are habitats on which P. contorta is dominant, exhibits a population structure of several age classes, and has no competition from any of the three species mentioned here. Where vast expanses of P. contorta forests occur throughout the Rocky Mountains, or more specifically in the Bighorns, there may simply be no seed source of any climax trees available for reinvasion of such sites. In these situations one might postulate that P. contorta is a seral species and will occupy the habitats for perhaps several hundred years until climax species again take over. There is also a possibility that widespread repeated

burning has sufficiently altered the soil characteristics that only P. contorta can maintain its population.

During a forest fire numerous changes occur any one or all of which could influence the course of succession afterward. The fact that P. contorta is favored by burning has long been observed in the Rocky Mountains.

During a fire, soil nutrients such as nitrogen and sulfur which are tied up in organic matter can be volatilized; others are deposited on the soil in the ash part of which may be absorbed in the soil and part of which may be washed away with subsequent rains. Repeated burning will affect not only the nutrient status of the soil, but can affect indirectly the water-holding capacity of the soil. Oxidation of organic matter, loss of nutrients, and direct destruction of plants is often accompanied by soil erosion making the soil even less capable of supporting a diverse vegetation. With fewer plants occupying the habitat, less organic matter available to be incorporated into the mineral soil, and erosion taking away the finer soil particles the total water-holding capacity is reduced. This can severely retard or even stop the successful establishment of the mesophytic Picea engelmannii and Abies lasiocarpa. In the absence of experimental data the above suggestions are offered to help explain the long-term persistence, even climax

status of P. contorta over part of its range in the Bighorns. Based on very limited results of pot culture tests, Reed (1969) suggested the lack of a seed source was more important than soil fertility for apparent maintenance of P. contorta stands in the Wind River Mountains. In the Bighorns, the problem remains a bit more intractable. Seed sources of both Picea engelmannii and Abies lasiocarpa are relatively close to stands of P. contorta which I consider to be climax. At the xeric edge of its range in the Bighorns P. contorta is slowly replaced by Pseudotsuga menziesii old individuals of which escaped destruction by fire.

Pinus contorta - Arctostaphylos uva-ursi habitat type.

This habitat type is confined to poor soils of granitic origin. The pH values of the upper dm of mineral soil range from 5.4 to 5.6 and the cation exchange capacity ranges from 7.21 to 10.9 meq/100 g (mean = 8.2 meq/100g). Exchangeable calcium of the upper dm ranges from 4.33 to 7.98 meq/100 g (mean = 5.45 meq/100g) and the total nitrogen ranges from .015% to .082% (mean = .048%) (Table G, App. II). Though soil moisture data were not obtained in this study I am of the impression that lack of soil moisture is an important limiting factor particularly for establishment of mesophytic Picea engelmannii and Abies lasiocarpa. Undergrowth vegetation

is not everywhere abundant in this habitat type and Peltigera sp. covers considerable patches of the mineral soil.

The self-reproducing population of P. contorta, the lack of invading Picea engelmannii and/or Abies lasiocarpa along with Arctostaphylos uva-ursi as the dominant undergrowth species are diagnostic features of the habitat type. The soil nitrogen content is also significantly less than that of the P. contorta - Vaccinium scoparium habitat type described below. The average number of undergrowth species in the stands studied was 18/125 m<sup>2</sup>. Both Spiraea betulifolia and Solidago spatulata are quite abundant in this habitat type and they decrease significantly in the P. contorta - Vaccinium scoparium habitat type.

Finally, it is important to point out that there are no Picea engelmannii-or Abies lasiocarpa-dominated forests in the Bighorns having the Arctostaphylos uva-ursi undergrowth union.

Pinus contorta - Vaccinium scoparium habitat type.

This habitat type also occurs primarily in the central one third of the Bighorns on granitic-derived soils. The habitats appear to be too xeric for Picea engelmannii or Abies lasiocarpa to successfully become established; however experimental evidence to support this statement is lacking.

Pinus contorta is again the sole dominant of the overstory, and in all the stands studied or observed several age classes of this species are present. Not all the stands have abundant seedlings or saplings, so reproduction has not been consistent with time. This may be related to the serotinous v. nonserotinous habit of individuals in populations. It may also relate to other factors affecting the establishment of seedlings. But the absence of P. engelmannii and A. lasiocarpa makes it impossible in my thinking, to categorize these stands as anything other than Pinus contorta habitat type. Whether they should be considered P. contorta habitat type or P. contorta "community type" (Reed 1969, Pfister et al. 1974) is of some fundamental synecologic importance. I have presented my reasons for suggesting these Pinus contorta-dominated stands should be thought of in terms of habitat types. Even if they are in the long term, over several hundred years, seral to Picea engelmannii or to Abies lasiocarpa, these stands meet the criteria for habitat type status. If necessary, the classification problem could more directly be approached by experimental field studies. Otherwise, all stand data of vegetation and soils are included at the end of this report; possible alternative interpretations may be derived from these data.

The undergrowth in both these P. contorta-dominated habitat types is sparse. In the more mesic P. contorta -

Vaccinium scoparium habitat type Poa interior, Poa nervosa, Arnica cordifolia and Epilobium angustifolium are all more frequent and constant than in the P. contorta - Arctostaphylos uva-ursi habitat type. (Table E, App I).

A description of the soil profile of stand 54, representative of the Pinus contorta - Vaccinium scoparium habitat type follows:

This soil is a member of the coarse-loamy, mixed family of Dystric Cryochrepts.

Pedon: (Colors are for moist soil unless otherwise noted.)

- 01      3-2 cm.--Needles, cones, and twigs
- 02      2-0 cm.--Decomposed organic matter
- All     0-3 cm.--Brown (10YR 5/3) loam; weak fine crumb structure that parts to weak very fine crumb; soft, very friable, slightly plastic; common roots; medium acid (pH 5.65 in 0.01 M CaCl<sub>2</sub>); abrupt wavy boundary.
- A12     3-12 cm.--Dark brown (10YR 3/3) sandy loam; weak fine crumb structure that parts to weak very fine crumb; soft very friable slightly sticky, slightly plastic; 5 percent granitic gravel; common roots; strongly acid (pH 5.35 in 0.01 M CaCl<sub>2</sub>); abrupt wavy boundary.
- B2      12-26 cm.--Yellowish brown (10YR 5/4) sandy loam; weak medium subangular blocky structure that parts to weak fine subangular blocky; slightly hard, friable, slightly sticky, slightly plastic; 10 percent granitic gravel; few roots; very strongly acid (pH 4.89 in 0.01 M CaCl<sub>2</sub>); clear wavy boundary.

C 26-74 cm.--Dark yellowish brown (10YR 4/4)  
sandy loam; massive; slightly hard,  
friable, slightly sticky, slightly  
plastic; 15 percent granitic gravel and  
cobbles; very strongly acid (pH 4.91  
in 0.01 M CaCl<sub>2</sub>).

Pfister et al. (1974) described a Pinus contorta -  
Vaccinium scoparium community type in Montana which shares  
with the P. contorta - Arctostaphylos uva-ursi and P.  
contorta - Vaccinium scoparium habitat types of the Bighorns  
such conspicuous species as Juniperus communis, Arnica  
cordifolia, and Epilobium angustifolium. In the Wind  
River Mountains Reed (1969) recognized two Pinus contorta-  
dominated community types both of which he considered to  
be seral to Abies lasiocarpa- or Picea engelmannii-dominated  
habitat types.

In the Black Hills Pinus contorta is present in only  
one stand of about 35 ha in the central area. Little  
additional information is reported for this stand (Thilenius  
1971).

#### Picea engelmannii Series

Forests in the Bighorns in which Picea engelmannii  
replaces Pinus contorta as the climax dominant are here  
grouped into the P. engelmannii series even though only one  
habitat type is involved. These forests range in elevation  
from 2000 to 2600 m overlapping those of the P. contorta  
series; however, the P. engelmannii forests occur on more

mesic habitats than those dominated by P. contorta which remains an important seral species in the P. engelmannii-dominated forests. Stands of this series are located primarily in the central third of the Bighorns. On the west side of the Mountains Picea- and Pseudotsuga-dominated forests extend down to the shrub-steppe vegetation. Along most of the lower western flank Pseudotsuga is the dominant species; but on more favorable habitats P. engelmannii extends down to the lowest edge of the coniferous forest.

All Picea in the Bighorns is referred to as P. engelmannii; however, studies have shown the species has hybridized and introgressed with P. glauca (Daubenmire 1974). Two locations where Daubenmire (1974) made mass collections for his study are near Powder River Pass at a high elevation and just west of Meadowlark Lake at a relatively low elevation. Casual observations made during the present study indicate that hybrid populations of Picea occur rather widely in the Bighorns. In Montana Pfister et al. (1974) reported hybridization to be widespread and hypothesized that these hybrid populations might be better adapted to occupy habitats below the limits of Abies lasiocarpa. A systematic study done in the Bighorns might be of value to determine if this hypothesis can be proven for the Picea-dominated zone described here.

Additionally, it might be valuable to study these hybrid populations in the Bighorns in relation to such characteristics as productivity, reproductive capacity, and disease and insect susceptibility.

Picea engelmannii - Vaccinium scoparium habitat type.

This habitat type occurs mainly on granitic substrates, though to a lesser extent it also occurs on glacial moraines. It is found primarily in the central one third of the Bighorns, and its elevational range of 2012 to 2621 m overlaps that of the Pinus contorta - Vaccinium scoparium habitat type. Picea-dominated sites are somewhat more mesic than P. contorta-dominated sites, and the Picea - Vaccinium habitat type occurs on nearly level topography or on slopes facing northwest to north. Pinus contorta is an important seral species in this habitat type; in the stands sampled this species had a basal area of 10 to 68 m<sup>2</sup>/ha. In most of the stands Picea is less abundant and had a basal area of 1 to 42 m<sup>2</sup>/ha. However, the presence of vigorous seedlings and saplings plus the presence of a seed source indicates quite clearly a successional trend toward Picea dominance. A few individuals of Abies lasiocarpa can be found in stands of this habitat, but the numbers are few, reproduction is poor, and there is no clear indication that this species will ever be climax in this habitat type.

Stands of this habitat type fall into three general age categories as judged from xylem layer (at breast height) counts of the largest trees in the stands. One group of stands exhibits an age range of 61 to 70 years, the second group ranges from 129 - 150 years, and the third group ranges from 216 to 265 years. These xylem layer data probably indicate approximate times of past disturbance of these stands of vegetation. Additionally, as determined from the tree data, there is evidence that following disturbance in the past, both Pinus contorta and Picea engelmannii become established simultaneously. However, because of the more abundant seeds, especially following fires, Pinus contorta quickly outnumbered the climax Picea engelmannii; and even after 265 years (stand 31) P. contorta is still an abundant seral species.

The undergrowth of this habitat type is dominated by Vaccinium scoparium with an average coverage of 41%. Other important species of the undergrowth include Juniperus communis, Poa nervosa, Antennaria racemosa, Arnica cordifolia, Epilobium angustifolium (always vegetative), Fragaria virginiana, Lupinus argenteus, Rosa acicularis, and Senecio streptanthifolius. Though most of these undergrowth species are shared with the Vaccinium scoparium union of the P. contorta - V. scoparium habitat

type, there is a limited number of species which are characteristic of one or the other of these two habitat types and can therefore be useful indicator species. The characteristic species and their constancies are as follows:

Picea engelmannii -  
Vaccinium scoparium  
habitat type.

Pinus contorta -  
Vaccinium scoparium  
habitat type

Vaccinium scoparium 11/11  
Antennaria racemosa 9/11  
Fragaria virginiana 8/11

Vaccinium scoparium 11/11  
Antennaria rosea 7/11  
Poa interior 9/11  
Trisetum spicatum 8/11

Edaphic characteristics of these two habitat types are very similar (Table G, App. II). In fact, between these two habitat types, there are no significant differences in any of the edaphic factors determined.

Reed (1969) described a Picea engelmannii - Vaccinium scoparium habitat type in the Wind River Mountains of northwestern Wyoming in which P. engelmannii was the primary climax dominant though Abies lasiocarpa was also present and reproducing in some of the stands studied. The Picea - Vaccinium habitat type in the Wind River range has few species in common with the counterpart habitat type in the Bighorns. The two habitat types have abundant Vaccinium scoparium, Arnica cordifolia, Poa nervosa, and Epilobium angustifolium. In the Bighorns I encountered 67 undergrowth species in the 11 stands repre-

senting this habitat type; Reed (1969) listed 40 undergrowth species in the 11 stands of the habitat type in the Wind River Mountains. Using the familiar expression,  $200w/a+b$ , (Oosting 1956) to determine floristic similarity I calculated 43% similarity between these two habitat types with the Picea - Vaccinium habitat type of the Bighorns having a decidedly more luxuriant flora. In Montana there is apparently no direct counterpart to these habitat types, though Pfister et al. (1974) describe several P. engelmannii-dominated habitat types in which Vaccinium scoparium is part of the undergrowth. In their P. engelmannii - Linnaea borealis habitat type Vaccinium scoparium occurs quite commonly in places. In the Black Hills to the east Picea engelmannii does not occur, but there is a Picea glauca - Vaccinium scoparium habitat type which occupies very mesic habitats of that range on both limestone- and granitic-derived soils (Thilenius 1971).

#### Abies lasiocarpa series

Over a wide geographic area in the Rocky Mountains the highest zone of coniferous forest is dominated by Abies lasiocarpa and Picea engelmannii. These forests are often referred to as subalpine though the dominants can extend to quite low elevations of canyons where adequate

moisture and cold temperatures provide suitable microclimates. In general the upper elevational limits of these forests range from 2100+ m in the region centered on the U. S.-Canadian border to about 3660 m in New Mexico. In a given region there is considerable variation in both the upper elevational limits and the elevational span of this zone.

Daubenmire (1943) reported that in general the altitudinal range of the "spruce-fir zone" is about 610 m. In the Medicine Bow Mountains of southeastern Wyoming Oosting and Reed (1952) found that Picea-Abies vegetation reaches 3535 m and extends down to 2500 m in moist canyons, but the best stands occur between 2987 and 3230 m. In the Wind River Mountains in northwestern Wyoming Reed (1969) studied Picea- and Abies- dominated vegetation in stands ranging from 2387 to 2991 m elevation. In the Bighorn Mountains stands of the Abies lasiocarpa series occur from 2300 to 2830 m. Upper timberline in the Bighorns is 3000 to 3100 m. In Montana that portion of the Abies lasiocarpa forest designated as subalpine occupies habitats from 1980 to 2195 m in the northwest part, 2225 to 2440 m in the west-central part, and 2470 to 2680 m in the southern part (Pfister et al. 1974).

The habitat types described for this series are all named with Abies lasiocarpa listed as the climax dominant. Data from the Bighorns warrant categorizing Picea engelmannii as a second climax species. The decision to use Abies lasiocarpa in the nomenclature of these habitat types was based on the desirability of being consistent with usage proposed by Daubenmire and Daubenmire (1968), and later used by Pfister et al. (1974) and Reed (1969). Except for the Abies lasiocarpa - Vaccinium scoparium habitat type in eastern Washington and northern Idaho, Abies does eventually replace other tree species in vegetation in which it is a climax species (Daubenmire and Daubenmire 1968). In Montana Picea engelmannii is listed as a seral species in all Abies lasiocarpa-dominated habitat types except the high elevation Pinus albicaulis - Abies lasiocarpa and the Larix lyallii - Abies lasiocarpa habitat types where it is listed as climax (Pfister et al. 1974). Reed (1969) described an Abies lasiocarpa - Pyrola secunda habitat type occurring in the Wind River Mountains in which Picea engelmannii is an important codominant. Reed (1969) suggested that the reproduction of Picea was considerably less than that of Abies though a mature stand of Abies-dominated vegetation would likely still have a few Piceas present. Oosting and Reed (1952) studied Picea

engelmannii - Abies lasiocarpa vegetation in eight stands in the Medicine Bow Mountains; they describe the ecologic roles of these two tree species, based in part on a review of the literature and in part on their own observations.

In the Bighorns I studied 34 stands of vegetation representative of Abies lasiocarpa - dominated vegetation. As judged from xylem layer counts on increment cores taken at breast height from the largest trees in the stands, the stands ranged in age from 90 to 410 years. In most of these stands Pinus contorta is present as a seral species, and in a few of the stands (e.g. stands 39, 86, 57) it is represented in several size classes and has the appearance of a self-perpetuating species (Table A, App. I). This contrasts with findings of Despain (1973) who reported that Pinus contorta was only an occasional member of the Picea-Abies vegetation. In several of the older stands (e.g. stands 41, 74, 89 etc.) Pinus contorta is not present. It is not uncommon for climax species to immediately regenerate on their habitats following disturbance (Daubenmire and Daubenmire 1968). Following disturbance of vegetation in this series both Abies and Picea can reinvade habitats immediately with or without Pinus contorta, depending on type of disturbance, avail-

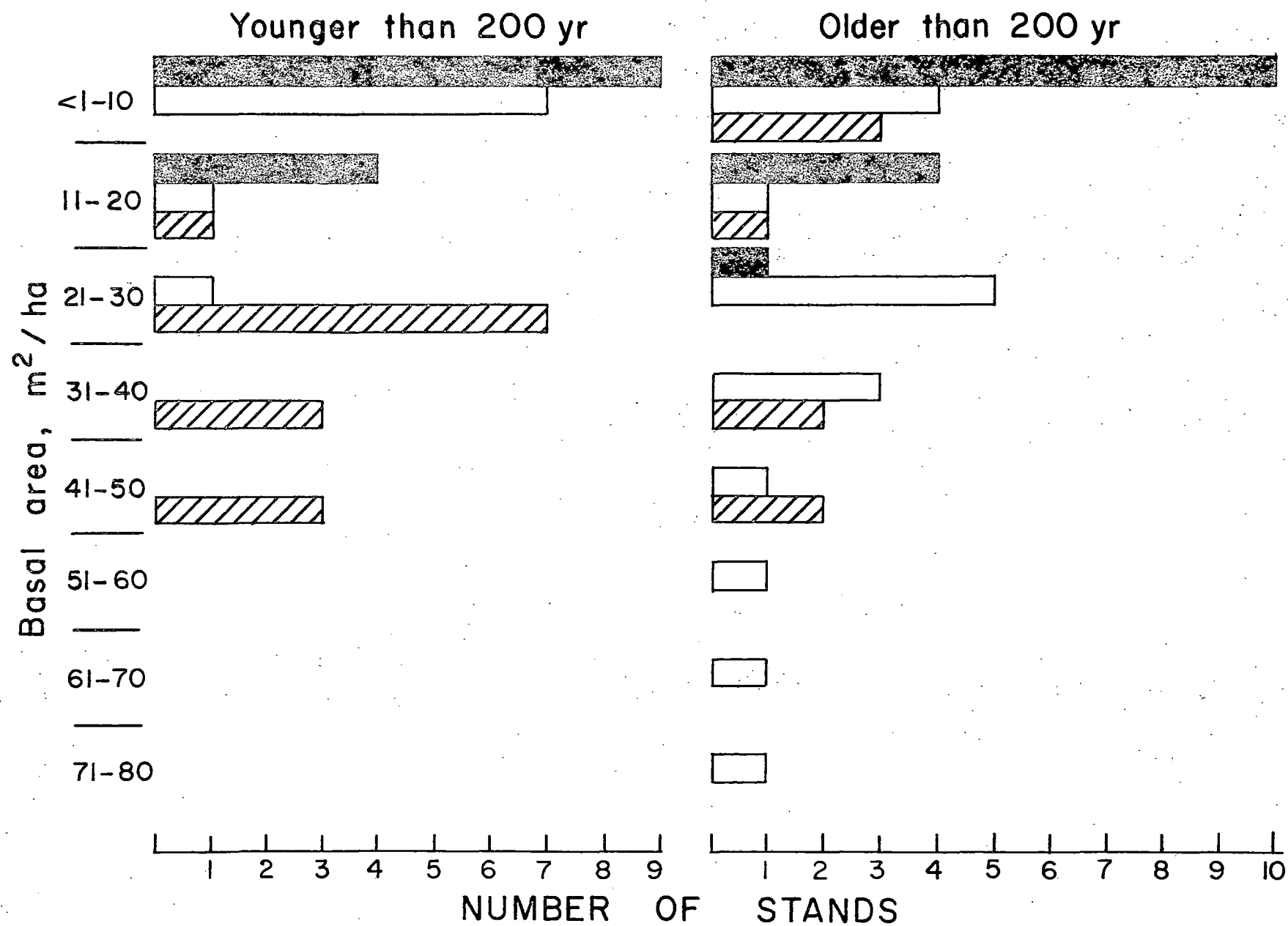
ability of seeds, etc. Pinus contorta is a less vigorous invader of habitats the soils of which are derived from sedimentary substrates than those having soils of granitic origin. Most of the young Abies lasiocarpa in the stands studied were produced by layering; on the other hand most of the young Picea engelmannii were produced from seed. This difference gives rise to considerable difference in numbers of young individuals of these two species with Abies far outnumbering Picea in most stands. (Table A, App. I).

In the oldest stands of Abies - Picea vegetation there is little evidence that Abies will replace Picea entirely. The largest size class represented by Abies in any stand was 4 - 5 dm and that occurred in only one stand. If Abies were to replace Picea completely 400 years should be adequate time to at least clearly indicate the trend. But in stand 74, 385+ years old, seedlings of Picea occur as well as individuals in size classes 2-3, 3-4, 4-5, and 7-8 dm dbh. In stand 41, 410+ years old, Picea was present in size classes 3-4, 4-5, and 5-6 dm dbh, and no seedlings were present.

Basal areas vary considerably in stands of the Abies lasiocarpa habitat types. The ranges of basal areas, the grouping of stands into less than and greater than 200 years, and the number of stands in which trees occur

in these categories are diagrammed in Fig. 1. In all stands regardless of age, basal areas of Abies never exceed  $30 \text{ m}^2/\text{ha}$ , and in most stands its basal area is less than  $10 \text{ m}^2/\text{ha}$  (Fig. 1). Pinus contorta is more likely to occur in stands less than 200 years old; whether in younger or older stands however, its basal area does not exceed  $50 \text{ m}^2/\text{ha}$ . Basal area of Picea engelmannii exhibits a marked difference in stands younger and stands older than 200 years. In stands younger than 200 years its maximum basal area was  $30 \text{ m}^2/\text{ha}$ ; in stands older than 200 years its maximum basal area is  $74 \text{ m}^2/\text{ha}$ . Additionally, in these older stands Picea is present in all size classes (Fig. 1). Oosting and Reed (1952) reported a range 22.3 to  $67.8 \text{ m}^2/\text{ha}$  for basal area of Picea engelmannii and 4.1 to  $16.6 \text{ m}^2/\text{ha}$  for basal area of Abies lasiocarpa in the Medicine Bow Mountains. Despain (1973) reported a range of 29.8 to  $46.9 \text{ m}^2/\text{ha}$  for basal area of P. engelmannii and 0.6 to  $10.7 \text{ m}^2/\text{ha}$  for basal area of A. lasiocarpa in spruce-fir forests in the Bighorns. In the present study basal areas for P. engelmannii and A. lasiocarpa range from 0.2 to  $74 \text{ m}^2/\text{ha}$  and 0.5 to  $24 \text{ m}^2/\text{ha}$  respectively. Values found in the present study extend considerably the range of basal areas previously reported for both these dominant trees. Obviously, the selection of study sites has overwhelming influence on results; the total number of stands studied may also have an influence.

Fig. 1. Basal areas of tree species in Abies lasiocarpa-dominated habitat types. Data are plotted to show relationships among numbers of stands in which species occur within ranges of basal areas. Data are also segregated according to whether the stands are younger or older than 200 years. Solid bars represent Abies lasiocarpa; open bars represent Picea engelmannii; hatched bars represent Pinus contorta.



Abies lasiocarpa - Shepherdia canadensis habitat type. This habitat type occurs in a limited area along the west side of the Bighorns. It is possible this habitat type could be considered a phase of the Abies lasiocarpa - Vaccinium scoparium habitat type, and it could easily be categorized as such later. However, the abundance of Shepherdia is a very distinctive characteristic and at present I categorize the vegetation at the habitat type level. Rolston (1961) briefly described this same vegetation in his study in the Bighorns. There is apparently no counterpart to this habitat type in the Medicine Bow Mountains (Oosting and Reed 1952), the Wind River Mountains (Reed 1969) or in Montana (Pfister et al. 1974). However, in the Abies lasiocarpa - Clematis pseudoalpina habitat type in Montana, Shepherdia does reach a fairly high constancy (Pfister et al. 1974).

Only two stands of this habitat type were sampled in the Bighorns, both located in the Shell Creek drainage near Shell Ranger Station. The stands face northwest and northeast. Pinus contorta is an important seral species in this habitat type though the climax species are Abies lasiocarpa and Picea engelmannii. Pseudotsuga menziesii is also a seral species in this habitat type.

The Shepherdia canadensis union forms a conspicuous layer under which the Vaccinium scoparium union is present and well-represented. Linnaea borealis, Spiraea betulifolia, Rosa acicularis, Pyrola secunda, and Arnica cordifolia are all present. Less mesophytic species include Juniperus communis and Mahonia repens. No edaphic factors distinguish this habitat type from the Abies - Vaccinium habitat type described below.

Abies lasiocarpa - Vaccinium scoparium habitat type. This habitat type has two climax dominants, Abies lasiocarpa and Picea engelmannii. The ecology of these two species in the Bighorns has been discussed to some extent above. Oosting and Reed (1952) presented a concise description of the autecologies of these two species. In this habitat type Pinus contorta is an important seral species; Pseudotsuga is an occasional minor seral species. Basal areas of the three important trees of this habitat type, as determined from the 25 stands studied, are as follows:

	Range	Median
<u>A. lasiocarpa</u>	0.4 to 18 m <sup>2</sup> /ha	5.9 m <sup>2</sup> /ha
<u>P. engelmannii</u>	0.2 to 34 "	10 "
<u>P. contorta</u>	2.6 to 49 "	29 "

The undergrowth is dominated by Vaccinium scoparium with a constancy of 100%, an average cover of 47% (95%

conf. limits =  $\pm 4.6\%$ ). While Vaccinium forms an almost complete ground cover in numerous stands, its coverage may be as low as 10% in other stands. Other undergrowth species having a constancy of at least 70% (occurring in at least 18 of the 25 stands studied) include Poa nervosa, Antennaria racemosa, Arnica cordifolia, Epilobium angustifolium (always vegetative), Lupinus argenteus, Fragaria virginiana, Potentilla diversifolia, and Pyrola secunda. In all, 91 undergrowth species occurred in the 25 stands representing this habitat type.

The diagnostic characters of this habitat type include the presence of self-reproducing populations of Abies lasiocarpa and/or Picea engelmannii, and Vaccinium scoparium the dominant undergrowth species. Where Abies lasiocarpa is not readily apparent in the stand, an effort should be made to find it as its presence or absence is the key to whether the vegetation will be categorized as P. engelmannii - Vaccinium scoparium or A. lasiocarpa - V. scoparium. Soil characteristics of upper dm samples of the mineral soil of this habitat type do not differ from those of the Picea - Vaccinium habitat type.

The Abies lasiocarpa - Vaccinium scoparium habitat type, or others very similar to it, occur throughout a large region of the Rocky Mountains. Daubenmire (1943)

reported that the Picea - Abies forest on the east side of the Rockies has scant undergrowth "dominated by dwarf vacciniums especially Vaccinium scoparium, Arnica cordifolia, Carex geyeri..." Marr (1961) very briefly described Picea - Abies vegetation in the Front Range of Colorado in which characteristic undergrowth species included Vaccinium myrtillus or V. scoparium, Carex rossii, Pedicularis racemosa, Arnica cordifolia, and sometimes Rosa acicularis. Despain (1973) described the undergrowth of Picea - Abies forests in the Bighorns as sparse consisting of Ribes lacustre, R. montigenum, Pyrola secunda, Vaccinium scoparium, Arnica cordifolia, and Epilobium angustifolium; but most of the ground cover was attributed to mosses and lichens. Reed (1969) described a Picea engelmannii - Vaccinium scoparium habitat type in the Wind River Mountains which is the counterpart of the Abies - Vaccinium habitat type of the present study in the Bighorns. Reed (1969) described the prominent undergrowth species as Polygonum bistortoides, Pedicularis bracteosa, and Potentilla diversifolia. In Montana the Abies - Vaccinium habitat type "constitutes most of the highest elevation forest belt...east of the continental divide" (Pfister et al. 1974). The habitat type in Montana differs from its counterpart in the Bighorns by having considerable Pinus albicaulis.

Abies lasiocarpa - Arnica cordifolia habitat type,

Some of the oldest Abies - Picea-dominated forests in the Bighorns are on heavy-textured shale-derived soils.

Seven stands representing the Abies - Arnica habitat type were sampled; their elevations ranged from 2548 to 2731 m and aspects of their exposures ranged from 244° to 92°. Seral trees in this habitat type include Pinus contorta and Pseudotsuga menziesii; in the present study these trees were present in only two of the seven stands studied. Abies - Arnica forests are characterized by much fallen timber and sparse undergrowth, especially in older stands. Vaccinium scoparium is absent, or very rare in this habitat type; it was absent in all seven stands studied. The conspicuous and constant undergrowth species is Arnica cordifolia. Ribes lacustre, Poa nervosa, Antennaria racemosa, Epilobium angustifolium (always vegetative), Fragaria virginiana, Galium boreale, and Thalictrum occidentale all occurred in at least 5 of the 7 (70%) stands studied. Allium brevistylum, Arnica latifolia, Lupinus argenteus, Moneses uniflora, and Pyrola secunda all occurred in 4 of the 7 stands studied. In all, there were 70 species of undergrowth plants encountered in the 7 stands.

Significant diagnostic characteristics of this habitat type are the self-reproducing population of Abies lasiocarpa, and sometimes Picea engelmannii,

along with the virtual absence of Vaccinium scoparium and the constant occurrence of Arnica cordifolia. In some stands Picea is present in only very large size classes, but close scrutiny will invariably reveal at least limited numbers of seedlings in the vicinity. Certain soil characteristics also distinguish this habitat type from the Abies - Vaccinium habitat type and the Picea - Vaccinium habitat type. A comparison of soil characteristics which are significantly different for the Abies - Arnica and Abies - Vaccinium habitat types are given in Table 2. These soil differences are ecologically important, and provide additional justification for recognizing distinct habitat types based on these stand data.

A soil profile description of stand 41, representative of the Abies - Arnica habitat type follows:

This soil is a member of the very fine, montmorillonitic family of Aquic Cryoborolls.

Pedon (Colors are for moist soil unless otherwise noted.)

- 01 10-9 cm.--Needles, cones and twigs
- 02 9-0 cm.--Decomposed organic matter; many roots.
- All 0-12 cm.--Mixed brown (7.5YR 5/2), black (5YR 2.5/1) silty clay loam; moderate fine granular structure; slightly hard, friable, sticky, plastic; many coarse roots; clay films on ped faces; slightly acid (pH 6.32 in 0.01 M  $\text{CaCl}_2$ ); clear wavy boundary.

- A12      12-47 cm.--Mixed very dark grayish brown (10 YR 3/2), very dark gray (10YR 3/1) silty clay; strong very fine angular blocky structure; slightly hard, friable, sticky, plastic; clay films on ped faces; neutral (pH 6.70 in 0.01 M  $\text{CaCl}_2$ ); clear wavy boundary.
- C          47-100 cm.--Dark grayish brown (2.5YR 4/2) silty clay; strong very fine angular blocky structure; hard, friable, very sticky, very plastic; clay films on ped faces; mildly alkaline (pH 7.37 in 0.01 M  $\text{CaCl}_2$ ).

At the 60 cm depth the soil was saturated with water; below this gravitational water was noted.

The only other habitat type of the same name occurs in Montana where the vegetation and environment are somewhat similar to the Abies - Arnica habitat type in the Bighorns (Pfister et al. 1974), except sites in the Bighorns are apparently more mesic and probably cooler. Undergrowth species of the Abies - Arnica habitat type shared in at least 50% of the stands in Montana (Pfister et al. 1974) and in the Bighorns are Arnica cordifolia, Fragaria virginiana, Pyrola secunda, and Thalictrum occidentale. Two additional species important in this vegetation in Montana but not in the Bighorns are Aster conspicuus and Osmorhiza chilensis. Undergrowth similarity between Montana and Bighorn stands of this habitat type was calculated with a coefficient of similarity (p. 53) using only species which were present in at least 50% of the stands. In so doing the calculated similarity is 50%.

Table 2. Mean values, 95% confidence limits, and calculated t values for those soil factors the means of which are significantly different for upper dm mineral soil samples from stands of the Abies lasiocarpa - Vaccinium scoparium and Abies lasiocarpa - Arnica cordifolia habitat types.

Soils Characteristics	Habitat Types		Calculated t values <sup>a</sup>
	<u>Abies lasiocarpa</u> - <u>Vaccinium scoparium</u>	<u>Abies lasiocarpa</u> - <u>Arnica cordifolia</u>	
pH	5.3 ( <u>±.10</u> )	6.0 ( <u>±.37</u> )	5.688
Exchangeable Calcium, meq/100 g	10.6 ( <u>±2.00</u> )	51.0 ( <u>±11.0</u> )	11.68
Percent Organic Matter	6.04 ( <u>±.751</u> )	10.6 ( <u>±1.36</u> )	5.611
Percent Nitrogen	.184 ( <u>±.022</u> )	.327 ( <u>±.055</u> )	5.468
Percent Clay	18.8 ( <u>±2.32</u> )	29.0 ( <u>±5.44</u> )	3.809

<sup>a</sup>Calculated t values are all significant at the .01 probability level.

Finally, I found no advantage in subdividing the elevational range of Abies lasiocarpa forests into montane and subalpine groups. Pinus contorta and even Pseudotsuga menziesii are seral species in both Abies - Vaccinium and Abies - Arnica habitat types which would be considered montane according to criteria offered by Pfister et al. (1974). At higher elevations on talus slopes, on wind swept ridges, or even in more protected habitats near upper timberline, clumps of poorly developed trees of Abies lasiocarpa, Picea engelmannii, and even Pinus contorta occur. Pinus albicaulis is present in a few of these high elevation sites but it is not abundant. Very little reproduction, aside from layering, is successful in these groves of trees many of which are wind-trained and very compact. These highest elevation stands above the "forest line" (Daubenmire 1943) were not sampled quantitatively.

## KEY TO THE FOREST HABITAT TYPES OF THE BIGHORN MOUNTAINS

1. Conifers absent or rare, not reproducing; dominant tree species is Populus tremuloides  
..... POPULUS TREMULOIDES - LUPINUS ARGENTEUS H.T.
1. Conifers present and reproducing in the habitat
  2. Pinus ponderosa present; other conifers absent
  3. Undergrowth dominated by herbaceous species; grasses particularly important
    4. Agropyron spicatum dominant in the undergrowth; Balsamorhiza sagittata also conspicuous  
..... PINUS PONDEROSA - AGROPYRON SPICATUM H.T.
    4. Festuca idahoensis dominant in the undergrowth; habitat somewhat more mesic than above  
..... PINUS PONDEROSA - FESTUCA IDAHOENSIS H.T.
  3. Undergrowth dominated by shrubby species
    5. Juniperus communis dominant in the undergrowth; Spiraea betulifolia, Symphoricarpos albus, and Mahonia repens may also be conspicuous  
..... PINUS PONDEROSA - JUNIPERUS COMMUNIS H.T.
    5. Juniperus communis absent or rare in the undergrowth
      6. Spiraea betulifolia dominant in the undergrowth; Symphoricarpos albus and Mahonia repens may also be conspicuous. Physocarpus monogynus absent or rare  
..... PINUS PONDEROSA - SPIRAEA BETULIFOLIA H.T.
      6. Physocarpus monogynus dominant in the undergrowth  
... PINUS PONDEROSA - PHYSOCARPUS MONOGYNUS H.T.
2. Coniferous trees other than Pinus ponderosa present and reproducing
  7. Pinus contorta, Picea engelmannii, and Abies lasiocarpa absent or at least not reproducing; Pseudotsuga menziesii reproducing satisfactorily

8. Physocarpus monogynus dominant in the undergrowth  
..... PSEUDOTSUGA MENZIESII - PHYSOCARPUS MONOGYNUS H.T.
8. Physocarpus monogynus absent or rare in the undergrowth
  9. Juniperus communis dominant in the undergrowth; Mahonia repens not abundant, may be absent; undergrowth generally sparse  
...PSEUDOTSUGA MENZIESII - MAHONIA REPENS H.T.  
JUNIPERUS COMMUNIS PHASE
  9. Juniperus communis present or absent in the undergrowth, not dominant; Mahonia repens dominant in the undergrowth  
...PSEUDOTSUGA MENZIESII - MAHONIA REPENS H.T.
7. Pinus contorta, Picea engelmannii, or Abies lasiocarpa present. Pseudotsuga menziesii may be present but not reproducing satisfactorily
10. Pinus contorta reproducing; no evidence of invasion by Picea engelmannii, Abies lasiocarpa, or Pseudotsuga menziesii
11. Undergrowth dominated by Arctostaphylos uva-ursi; Vaccinium scoparium absent or rare  
..... PINUS CONTORTA - ARCTOSTAPHYLOS UVA-URSI H.T.
11. Undergrowth dominated by Vaccinium scoparium; Arctostaphylos uva-ursi absent or rare  
PINUS CONTORTA - VACCINIUM SCOPARIUM H.T.
10. Picea engelmannii and/or Abies lasiocarpa dominant and reproducing; Pinus contorta and/or Pseudotsuga menziesii may be present but reproducing insufficiently to maintain population
12. Abies lasiocarpa absent; Picea engelmannii dominant. Undergrowth dominated by Vaccinium scoparium  
..... PICEA ENGELMANNII - VACCINIUM SCOPARIUM H.T.

12. Both Picea engelmannii and Abies lasiocarpa dominant

13. Undergrowth dominated by Shepherdia canadensis

..... ABIES LASIOCARPA - SHEPHERDIA  
CANADENSIS H.T.

13. Shepherdia canadensis absent or rare,  
not dominant in the undergrowth

14. Undergrowth dominated by Vaccinium scoparium

..... ABIES LASIOCARPA - VACCINIUM  
SCOPARIUM H.T.

14. Undergrowth dominated by Arnica cordifolia; Vaccinium scoparium  
absent or rare

..... ABIES LASIOCARPA - ARNICA  
CORDIFOLIA H.T.

## DISCUSSION

Habitat type classification. A habitat type classification of forest lands is thought to be a natural classification in that vegetation dynamics and their expressions are recognized and described and in which pertinent ecosystem characteristics in addition to vegetation are recognized. Obviously, much of what is important to know about ecosystems is not learned from the initial habitat type classification, but the initial study does provide the framework within which other studies on the ecosystems can relate.

In this study, as in numerous others indicated above, vegetation is utilized as the principle component of the classification scheme. Reasons for this are quite understandable. It is convenient to recognize habitat types by their climax, or potentially climax, vegetation. Within the classification system, additional studies may relate to tree growth rates (Daubenmire 1961, Roe 1967), to the possibility of predicting and coping with disease susceptibility of important tree species, to recognizing suitable browse production areas following disturbance, and to correlations between vegetation and edaphic factors (Daubenmire 1973).

Recognizing habitat types also allows mapping of recognizable land units which have significant similarities and/or dissimilarities. It has been argued that variation

in vegetation is continuous to the extent that discontinuities can only be delimited arbitrarily. The approach used in this study, as by others (Daubenmire and Daubenmire 1968, Reed 1969, Pfister et al. 1974), has not been that of ignoring variation in the vegetation, but rather, and this is really more central to the issue, to recognize the discontinuities within the vegetational matrix as significant changes in the vegetation. There is sufficient evidence to suggest that an ecologic approach which distinguishes seral from climax species, recognizes self-perpetuating populations, recognizes that not all species are of equal ecologic importance, and attempts to relate abiotic factors with biotic factors will also recognize significant discontinuities in the vegetational gradients. Maps which result from intensive study of habitat types are permanent maps; they will reflect the potentialities of the land units and, if needed, suitable symbols can be utilized to indicate the nature of the current standing crops of vegetation on given habitat types. How landscapes can be classified and mapped into manageable units in large blocks of land where natural forests are the managed resource is an insurmountable problem if the discontinuities of the vegetation are unrecognized or ignored.

Finally, the habitat type approach attempts to clarify the importance of recognizing indicator species, and utilizing such species not only in the classification

scheme but also to signify possible important ecosystem differences. For example, the presence or absence of significant quantities of Arctostaphylos uva-ursi in Pinus contorta-dominated forests in the Bighorns is of prime ecologic importance which I attribute to moisture difference in soils between the Pinus contorta - Arctostaphylos uva-ursi and Pinus contorta - Vaccinium scoparium habitat types. At high elevations in the Bighorns, in Abies lasiocarpa - Picea engelmannii dominated vegetation, the absence of Vaccinium scoparium is of singular importance. Several edaphic factors correlate directly with the absence of Vaccinium in the Abies - Arnica habitat type including pH, calcium, organic matter, nitrogen, and clay contents.

It is also important that individual tree species are climax over a segment of the landscape permitting a comparison of habitat types dominated by a particular tree species in the Bighorns with those in other areas of the Rockies which have the same climax dominant.

Biotic succession. A fundamental concept in vegetation science is that of biotic succession---changes with time in population structures of species in a given habitat until change is imperceptible. At this time populations are in apparent steady state with their environments and the condition of the biotic community

is referred to as climax. When disturbed, all forest vegetation in the Bighorns can redevelop along various lines of succession. Climax vegetation can regenerate directly onto sites it previously occupied, or it can be replaced temporarily (sometimes for several hundred years) by seral communities. Opening up a biotic community generally allows the introduction of heliophytic species which can hide much of the climax undergrowth. Pinus ponderosa, Pseudotsuga menziesii, and Pinus contorta all invade upslope or onto more mesic sites following disturbance of vegetation on the latter. Picea engelmannii and Abies lasiocarpa, on the other hand, exhibit no strong tendency to move downslope or onto more xeric sites following disturbance (Table 3). Pinus contorta is the only tree species in the Bighorns which moves both upslope and downslope following disturbance (Table 3). Pinus contorta is the most abundant tree in the Bighorns but much about its ecology there remains inadequately understood. Most stands of P. contorta were initiated following fire, and some stands remain extremely dense. Ordinarily fire favors this tree, but not all stands of P. contorta are seral or subclimax. In some, as noted earlier, the population structure is that of a self-reproducing species and there is little evidence that either Picea engelmannii

Table 3. The ecologic roles of tree species in the habitat types of the Bighorn Mountains. c = climax; S = major seral; s = seral.

Habitat type \ Species	<u>Pinus ponderosa</u>	<u>Pseudotsuga menziesii</u>	<u>Pinus flexilis</u>	<u>Populus tremuloides</u>	<u>Pinus contorta</u>	<u>Picea engelmannii</u>	<u>Abies lasiocarpa</u>
<u>Pinus ponderosa</u> - <u>Agropyron spicatum</u>	C						
<u>Pinus ponderosa</u> - <u>Festuca idahoensis</u>	C						
<u>Pinus ponderosa</u> - <u>Juniperus communis</u>	C						
<u>Pinus ponderosa</u> - <u>Spiraea betulifolia</u>	C						
<u>Pinus ponderosa</u> - <u>Physocarpus monogynus</u>	C						
<u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u> , <u>Juniperus communis</u> phase	S	C	s		s		
<u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u>	s	C	s		s		
<u>Pseudotsuga menziesii</u> - <u>Physocarpus monogynus</u>	S	C	s				
<u>Populus tremuloides</u> - <u>Lupinus argenteus</u>				C			
<u>Pinus contorta</u> - <u>Arctostaphylos uva-ursi</u>					C		
<u>Pinus contorta</u> - <u>Vaccinium scoparium</u>		s			C		
<u>Picea engelmannii</u> - <u>Vaccinium scoparium</u>		s			S	C	
<u>Abies lasiocarpa</u> - <u>Shepherdia canadensis</u>		s			S	C	C
<u>Abies lasiocarpa</u> - <u>Vaccinium scoparium</u>		s			S	C	C
<u>Abies lasiocarpa</u> - <u>Arnica cordifolia</u>		s			S	C	C

or Abies lasiocarpa will replace P. contorta as the climax dominant. There are some clearcut areas in the Bighorns onto which P. contorta is not invading even though there was expectation that it would. The only such area examined during the course of the present study appeared to be a Pinus contorta - Vaccinium scoparium or Picea engelmannii - Vaccinium scoparium habitat type. Lack of successful regeneration on these sites further exemplifies need for better understanding of either P. contorta or P. engelmannii, or both, in the Bighorns.

Species richness. The median number of species per 125 m<sup>2</sup> sample for each habitat type is shown in Table 4. In contrast to the Wind River Mountains (Reed 1969), undergrowth vegetation in habitat types of the Bighorns does not decrease in species richness with an increase in elevation. In fact the data (Table 4) appear to be distributed bimodally with a peak in the low elevation Pinus ponderosa - Physocarpus monogynus habitat type and another in the high elevation Abies lasiocarpa - Arnica cordifolia habitat type. Those habitat types having the fewest undergrowth species more consistently occur on granitic-derived soils except for the Pseudo-tsuga menziesii - Mahonia repens habitat type which is found on both granitic-derived and sedimentary-derived soils. Tree species richness is relatively simple in

Table 4. Species richness of the undergrowth in habitat types of the Bighorn Mountains.

Habitat type	Median number <sup>a</sup>	
	of undergrowth species	Number of stands studied
<u>Pinus ponderosa</u> - <u>Agropyron spicatum</u>	20	1
<u>Pinus ponderosa</u> - <u>Festuca idahoensis</u>	25	2
<u>Pinus ponderosa</u> - <u>Juniperus communis</u>	18	1
<u>Pinus ponderosa</u> - <u>Spiraea betulifolia</u>	26	2
<u>Pinus ponderosa</u> - <u>Physocarpus monogynus</u>	27	4
<u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u> , <u>Juniperus communis</u> phase	22	2
<u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u>	19	8
<u>Pseudotsuga menziesii</u> - <u>Physocarpus monogynus</u>	25	3
<u>Populus tremuloides</u> - <u>Lupinus argenteus</u>	24	4
<u>Pinus contorta</u> - <u>Arctostaphylos uva-ursi</u>	18	5
<u>Pinus contorta</u> - <u>Vaccinium scoparium</u>	20	11
<u>Picea engelmannii</u> - <u>Vaccinium scoparium</u>	18	11
<u>Abies lasiocarpa</u> - <u>Shepherdia canadensis</u>	25	2
<u>Abies lasiocarpa</u> - <u>Vaccinium scoparium</u>	25	25
<u>Abies lasiocarpa</u> - <u>Arnica cordifolia</u>	26	7

<sup>a</sup>Based on 125 m<sup>2</sup> per stand.

the Bighorns, though the data show a tendency of bimodal distribution (Table 3) with 4 tree species commonly occurring in the Pseudotsuga menziesii-dominated habitat types at intermediate elevations and 4 tree species occurring in Abies lasiocarpa-dominated habitat types at high elevations.

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APPENDIX I. Vegetational data of the intensively sampled  
stands in the Bighorn Mountains.

Table A. Tree population structures of each species in each stand listed by habitat types. Numbers of trees listed are per 375 m<sup>2</sup>; basal areas (b.a.) in m<sup>2</sup>/ha are given below stand numbers. Abbreviations of tree species are as follows:

Pn p --- Pinus ponderosa  
 Ps m --- Pseudotsuga menziesii  
 Pn f --- Pinus flexilis  
 Po t --- Populus tremuloides  
 Pn c --- Pinus contorta  
 Pc e --- Picea engelmannii  
 Ab l --- Abies lasiocarpa

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm								
		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
		<.5	>.5							
	1. <u>Pinus ponderosa</u> - <u>Agropyron spicatum</u> habitat type									
2 27.8	Pn p	3		10			1			1
	2. <u>Pinus ponderosa</u> - <u>Festuca idahoensis</u> habitat type									
5 23.6	Pn p	2	3	3	1			1	1	
7 42.6	Pn p		14	11	11	5		1		
	3. <u>Pinus ponderosa</u> - <u>Juniperus communis</u> habitat type									
62 49.3	Pn p	8	12	6	4	8	1	1	1	
	4. <u>Pinus ponderosa</u> - <u>Spiraea betulifolia</u> habitat type									
3 41.9	Pn p			1	3	10	1			
63 22.6	Pn p		2	6	4	4	1			

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
b.a.	Spp.	<.5	>.5							
5. <u>Pinus ponderosa</u> - <u>Physocarpus monogynus</u> habitat type										
6 28.7	Pn p	2	9	8	2			1		
8 38.4	Pn p	8	14	16	4					
9 60.2	Pn p	39	31	24	4					
79 16.2	Pn p	3	6	5	3	2	1			
	Pn f	1								
	Ps m	1								
6. <u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u> habitat type										
<u>Juniperus communis</u> phase										
16 31.9	Ps m	11		1	1					
	Pn p	10	3	4	4	4	2			
	Pn c	5	1	1	1					
	Pn f	2								
64 46.2	Ps m	213	7	3	7	2	1			
	Pn f	1	4	6	4	5	1			
	Pc e		1							
7. <u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u> habitat type										
26 63.3	Ps m	315	1	3	10	3	1		1	
	Pn f	2			1					
78 36.0	Ps m	720	5	8	13	2	1			
	Pn f		1	6	2					

Table A, cont'd.

Stand and b.a.	Spp.	Diameter (at breast height) classes in dm									
		0-1		1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
		<.5	>.5								
11 58.7	Ps m	301	32	11	5	2	4	2	1		
12 69.2	Ps m	3600	14	5	7	5	5	1			1
13 95.1	Ps m	165	16	19	27	8	3				
14 40.8	Ps m	26	7	7	15	4					
	Pc e	3			1						
	Pn c			2	5	5		1			
15 34.8	Ps m	31	4	13	9	4		1			
	Pn c	1									
68 65.2	Ps m	195	3	14	16	6	1				

8. Pseudotsuga menziesii - Physocarpus monogynus habitat type

77 13.2	Ps m		7	10	6						
20 35.8	Ps m	420	9	4	1						
	Pn p	8	10	20	7	5					
	Pn f	6	4								
70 30.2	Ps m	360	4	2	2						
	Pn p	15	29	25	5	2					
	Pn f	5	1								

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
b.a.	Spp.	<.5	>.5							
9. <u>Populus tremuloides</u> - <u>Lupinus argenteus</u> habitat type										
61	Po t	150 <sup>a</sup>	20	68						
35.7	Pc e	15								
19	Po t	1035	104	51	9					
47.1										
17	Po t	600	11	58	16					
48.5										
10	Po t	1920	3	43	2					
22.4										
10. <u>Pinus contorta</u> - <u>Arctostaphylos uva-ursi</u> habitat type										
47	Pn c	65	20	14	9	1				
23.9										
50	Pn c	53	2	1	1	5	4			
24.9										
51	Pn c	240		16	5	1				
36.4										
83	Pn c		19	56	7					
36.7										
84	Pn c	60	35	30	4	3				
31.4										
11. <u>Pinus contorta</u> - <u>Vaccinium scoparium</u> habitat type										
53	Pn c		2	4	19	8	1			
51.6										
85	Pn c	9	9	6	7	2				
18.1										
69	Pn c		9	16	14	3	1			
32.1										
	Pc e			1						

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
b.a.	Spp.	<.5	>.5							
67 45.0	Pn c	27	12	7	6	4	2		1	
	Ps m	1	3	2						
	Pc e	3	6							
	Pn f		1							
60 51.1	Pn c	90	4	10	14	9	1			
	Pc e		2							
58 33.0	Pn c	45	1	25	16					
	Pc e	3								
54 55.2	Pn c		3	26	25	6				
49 32.1	Pn c	8		8	16	2	1			
46 51.8	Pn c	38	4	8	6	10	1	1		
45 18.6	Pn c	90	1	36	1					
25 30.4	Pn c	540	9	8	8		1			

12. Picea engelmannii - Vaccinium scoparium habitat type

21 42.1	Pc e	75				1				
	Pn c		17	38	12					
	Ps m	15				1				
22 37.8	Pc e	15				1				
	Pn c	1	7	21	16	1				
	Ps m		5	2						

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1		1-2	2-3	3-4	4-5	5-6	6-7	7-8 8+
b.a.	Spp.	<.5	>.5							
24 32.5	Pc e	22	2	1			2			
	Pn c	7	12	29	2	2				
34 37.2	Pc e	45	10	8		1				
	Pn c	45	13	7	13	3				
48 31.1	Pc e	2				1				
	Pn c	15	12	11	5	6				
82 35.2	Pc e	1	1							
	Pn c	2	18	40	9	1				
	Po t	1			1					
52 21.7	Pc e	9	2	1						
	Pn c	14	20	11	5	1	1			
55 70.7	Pc e	27				1				
	Pn c	56	63	27	6	4	4			
29 59.7	Pc e	15		2						
	Pn c	7	2	4	16	9	3			
30 47.1	Pc e	16		1	1					
	Pn c	11	10	4	5	9	3			
31 52.3	Pc e	120	2	2	6	4	4	1		
	Pn c	15	3	1	3	2				

13. Abies lasiocarpa - Shepherdia canadensis habitat type

75 34.5	Ab l	80	6	6	2					
	Pc e		1	1						
	Pn c		1	8	14	3				

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
b.a.	Spp.	<.5	>.5							
76	Pc e	30	3							
22.7	Pn c	90	3	13	7	1	1			
	Ps m	15	1							
14. <u>Abies lasiocarpa</u> - <u>Vaccinium scoparium</u> habitat type										
81	Ab l	113 <sup>a</sup>	3		1					
33.9	Pn c		1	4	9	7				
35	Ab l	390	10		1					
51.0	Pn c		5	16	12	8	1			
36	Ab l	165	16	6		2	1			
36.8	Pn c	15	2	2	4	5	1			
39	Ab l	90	3							
40.1	Pn c	60	4	13	15	2	2			
40	Ab l	300	11	1	2	2				
37.6	Pn c			1	11	4				
	Ps m					1				
23	Ab l			1	1					
29.4	Pc e	30					1			
	Pn c	15	23	18	2	2				
	Ps m		1	1						
80	Ab l	15								
37.0	Pn c	165		1	13	6	1			

Table A, cont'd.

Stand and b.a.	Spp.	Diameter (at breast height) in dm								
		0-1		1-2	2-3	3-4	4-5	5-6	6-7	7-8 8+
		<.5	>.5							
86 35.5	Ab l	75	1			1				
	Pc e	30								
	Pn c	150	20	11	5	7				
44 37.0	Ab l	40		3	1					
	Pc e	2	3	6	3					
	Pn c	2	7	17	10	2				
59 27.0	Ab l	188		1						
	Pc e	540		5		2		1		
	Pn c	15	4	4	6	1				
1 55.6	Ab l	6			1					
	Pc e	22	2	2	2			1		
	Pn c	11	6	9	15	6	1			
28 47.0	Ab l	102	7	4	1					
	Pc e	7	1	2	1	5	1	1		
	Pn c			6	9	1				
56 43.3	Ab l	108	4	5	3					
	Pc e	21		1	1	4	1		1	
	Pn c				4	3	1			
57 42.8	Ab l	30			1					
	Pc e	49	3	6		1	1			
	Pn c	22	3	2	4	7	2			
92 45.7	Ab l	26	1	1						
	Pc e	6	5	3	2	2				
	Pn c			1	7	5	1	1		

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1		1-2	2-3	3-4	4-5	5-6	6-7	7-8 8+
b.a.	Spp.	<.5	>.5							
93 44.1	Ab l	25		1	1					
	Pc e		1		1					
	Pn c	45	6	1	6	5	3	1		
71 37.8	Ab l	375	10	3	3					
	Pc e	5	8	4					1	1
	Pn c		1	4		2				
	Ps m	10	1	1						
38 43.7	Ab l	155	32	7	2					
	Pc e	15			1					
	Pn c		2	9	9	4	1			
72 54.3	Ab l	136	16	4	3					
	Pc e	2	2							
	Pn c			8	15	9				
42 51.2	Ab l	30	1	1	1					
	Pc e				1					
	Pn c	82	1	2	13	10	1			
32 29.3	Ab l	60	7	7						
	Pc e	240	19	7			1	1	1	
73 43.7	Ab l	510	6	3	2	3	1			
	Pc e			2	3	4	2			
	Pn c				2					
88 42.4	Ab l	292	10	18						
	Pc e	68		8	2	7		1		

Table A, cont'd.

Stand		Diameter (at breast height) classes in dm								
and		0-1	1-2	2-3	3-4	4-5	5-6	6-7	7-8	8+
b.a.	Spp.	<.5	>.5							
90 30.4	Ab 1	840	23	9	5					
	Pc e	45			1	1			1	
91 43.4	Ab 1	19	23	13						
	Pc e				1	2	3	1	1	
15. <u>Abies lasiocarpa</u> - <u>Arnica cordifolia</u> habitat type										
33 62.4	Ab 1	12	1	1						
	Pc e	45	1	3	3	3	5	3		
	Ps m	37	2		2			1		
43 48.3	Ab 1	165	4	4	2					
	Pc e	2	2	3	3	1	1	1	1	1
37 34.6	Ab 1	150	2			1				
	Pc e	135					2			
	Pn c	15	7	17	7	2				
41 54.2	Ab 1	330	16	13	3					
	Pc e					3	2	4		
87 98.1	Ab 1	712	127	17	1					
	Pc e	22			1	2	1	4	3	1
89 81.6	Ab 1	1582	10	8	3					
	Pc e	210	2	3	4	4	2	5	1	
74 46.2	Ab 1	465	6	6	3					
	Pc e	17			6	2	3			1

a

Numbers of both Populus tremuloides and Abies lasiocarpa in this size class also include individuals produced vegetatively.

Table B. Undergrowth data of Pinus ponderosa dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but not in any microplot are indicated by \*. Other data included are stand location and topographic position.

Stand Number	2	5	7	62	3	63	6	8	9	79
Location:										
Section	3	27	35	28	14	2	35	23	27	15
Township	50N	49N	57N	48N	53N	50N	57N	56N	54N	56N
Range	83W	83W	87W	83W	84W	83W	87W	87W	85W	87W
Topographic Position:										
Slope	30°	10°	25°	17°	28°	23°	23°	24°	15°	23°
Aspect	150°	355°	25°	195°	175°	5°	25°	395°	330°	320°
Elevation, meters	1829	1818	1311	2341	1798	1731	1402	1628	1804	1646
% Coverage	C	C	C	C	C	C	C	C	C	C
% Frequency	F	F	F	F	F	F	F	F	F	F

#### LARGE SHRUBS

<u>Acer glabrum</u>	.	.	.	.	.	.	+	.30 2.0	.35 4.0	.
<u>Amelanchier alnifolia</u>	.	.	.	.	.	.	+	.	.	0.6 4.0
<u>Juniperus communis</u>	.	.	.	4.7 6.0	.	.	.	*	.	+
<u>Physocarpus monogynus</u>	.	.	.	.	.	.	19. 32.	44. 76.	31. 64.	79. 100
<u>Prunus virginiana</u>	0.1 4.0	.	1.8 12.	.	2.0 10.	*	1.2 8.0	.	0.3 2.0	.
<u>Rhus trilobata</u>	*	4.3 18.	.	.	.	.	.	.	.	.
<u>Ribes cereum</u>	+	.	.	.	.	*	.	.	.	.
<u>Shepherdia canadensis</u>	.	.	.	.	.	.	.	.	0.4	.

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
GRAMINOIDS										
<u>Agropyron spicatum</u>	$\frac{5.3}{38.}$	$\frac{0.4}{16.}$	$\frac{2.0}{28.}$	.	.	.	*	.	.	.
<u>Aristida longiseta</u>	$\frac{3.0}{30.}$	.	.	.	.	.	.	.	.	.
<u>Bromus tectorum</u>	$\frac{0.4}{6.0}$	$\frac{0.6}{4.0}$	$\frac{.85}{14.}$	.	.	.	$\frac{0.1}{4.0}$	.	.	.
<u>Carex filifolia</u>	$\frac{1.9}{34.}$	$\frac{1.4}{36.}$	$\frac{0.2}{6.0}$	$\frac{0.3}{12.}$	.	.	.	.	.	.
<u>Carex heliophila</u>	.	.	.	.	.	$\frac{0.3}{12.}$	.	.	.	.
<u>Carex xerantica</u>	.	.	.	.	.	.	$\frac{0.6}{6.0}$	.	.	.
<u>Elymus glaucus</u>	.	.	.	.	.	.	.	.	.	+
<u>Festuca idahoensis</u>	$\frac{0.3}{2.0}$	$\frac{6.7}{52.}$	$\frac{8.9}{67.}$	.	$\frac{0.3}{8.0}$	$\frac{0.4}{4.0}$	$\frac{0.4}{8.0}$	.	.	$\frac{0.8}{14.}$
<u>Hesperochloa kingii</u>	.	$\frac{1.2}{8.0}$	$\frac{1.2}{10.}$	$\frac{6.4}{70.}$	$\frac{0.3}{4.0}$	$\frac{1.0}{10.}$	$\frac{0.8}{10.}$	$\frac{0.9}{14.}$	$\frac{1.3}{22.}$	.
<u>Koeleria cristata</u>	$\frac{1.3}{12.}$	$\frac{0.6}{4.0}$	$\frac{0.4}{6.0}$	*	.	.	.	.	.	.
<u>Poa interior</u>	.	.	.	$\frac{0.6}{10.}$	*	$\frac{0.6}{26.}$	$\frac{1.0}{10.}$	$\frac{0.4}{6.0}$	.	$\frac{0.4}{6.0}$

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Poa palustris</u>	.	.	$\frac{4.8}{28.}$	.	$\frac{0.4}{8.0}$	.	$\frac{5.4}{40.}$	.	.	$\frac{1.1}{17.}$
<u>Poa pratensis</u>	+	+	$\frac{0.5}{10.}$	.	.	.	.	.	.	.
<u>Stipa columbiana</u>	.	.	.	.	.	.	$\frac{0.9}{12.}$	+	+	.
<u>Stipa comata</u>	$\frac{0.5}{10.}$	+	.	.	.	.	.	.	.	.
<u>Stipa viridula</u>	.	.	$\frac{1.2}{16.}$	.	$\frac{0.4}{8.0}$	.	$\frac{0.2}{8.0}$	.	.	.
LOW SHRUBS AND HERBS										
<u>Achillea millefolium</u>	.	*	$\frac{3.5}{40.}$	$\frac{0.2}{6.0}$	$\frac{0.4}{4.0}$	$\frac{0.3}{4.0}$	$\frac{1.5}{38.}$	$\frac{0.1}{4.0}$	.	$\frac{0.4}{14.}$
<u>Agoseris glauca</u>	.	.	$\frac{0.2}{6.0}$	$\frac{0.6}{12.}$	.	+	.	.	.	$\frac{0.3}{12.}$
<u>Allium cernuum</u>	.	.	$\frac{0.1}{4.0}$	.	$\frac{0.1}{4.0}$	.	.	.	.	.
<u>Allium textile</u>	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.
<u>Anemone patens</u>	.	.	$\frac{2.2}{10.}$	$\frac{0.3}{12.}$	.	$\frac{1.0}{18.}$	$\frac{0.8}{12.}$	$\frac{0.4}{8.0}$	.	$\frac{0.5}{12.}$
<u>Antennaria parviflora</u>	$\frac{0.8}{4.0}$	.	$\frac{0.7}{2.0}$	.	.	.	.	+	.	.

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Antennaria racemosa</u>	.	$\frac{0.1}{4.0}$	.	*	.	.	$\frac{0.3}{2.0}$	.	.	.
<u>Antennaria rosea</u>	.	+	$\frac{1.3}{10.}$	.	.	$\frac{1.1}{12.}$	$\frac{1.1}{6.0}$	$\frac{1.6}{10.}$	.	$\frac{0.2}{8.0}$
<u>Arenaria congesta</u>	.	.	.	.	.	$\frac{0.1}{8.0}$	.	.	.	.
<u>Arnica cordifolia</u>	.	.	.	+	.	+	.	$\frac{21.}{88.}$	$\frac{2.5}{22.}$	.
<u>Arnica sororia</u>	.	.	+	.	.	+	$\frac{0.2}{6.0}$	.	.	.
<u>Artemisia frigida</u>	$\frac{1.1}{14.}$	$\frac{0.8}{12.}$	.	.	.	.	.	.	.	.
<u>Aster conspicuus</u>	.	.	.	.	.	.	.	.	.	$\frac{2.2}{20.}$
<u>Astragalus miser</u>	.	.	.	$\frac{3.3}{22.}$	.	.	.	.	.	.
<u>Astragalus succulentus</u>	$\frac{0.8}{2.0}$	.	$\frac{6.1}{22.}$	.	.	.	.	.	.	.
<u>Balsamorhiza incana</u>	.	.	.	.	.	.	.	.	*	$\frac{0.4}{14.}$
<u>Balsamorhiza sagittata</u>	$\frac{0.2}{8.0}$	$\frac{8.2}{24.}$	$\frac{11.}{42.}$	.	$\frac{2.3}{24.}$	.	$\frac{3.8}{26.}$	.	.	.

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Besseyia wyomingensis</u>	.	.	.	.	.	$\frac{0.1}{2.0}$	.	.	.	.
<u>Bupleurum americanum</u>	.	.	.	.	.	.	.	.	.	$\frac{0.2}{4.0}$
<u>Castilleja gracillima</u>	.	.	.	.	.	.	.	$\frac{0.2}{4.0}$	.	.
<u>Cerastium arvense</u>	.	$\frac{1.6}{24.}$	$\frac{4.6}{46.}$	.	$\frac{0.2}{8.0}$	.	$\frac{2.0}{28.}$	+	.	$\frac{1.0}{40.}$
<u>Clematis columbiana</u>	.	.	.	.	.	.	.	+	$\frac{0.1}{2.0}$	.
<u>Clematis tenuiloba</u>	.	.	.	$\frac{1.1}{16.}$	$\frac{2.5}{14.}$	.	.	$\frac{0.6}{6.0}$	+	$\frac{1.9}{36.}$
<u>Corallorhiza striata</u>	.	.	.	.	.	.	.	+	.	.
<u>Crepis acuminata</u>	.	.	+	.	.	.	.	.	.	.
<u>Cystopteris fragilis</u>	$\frac{0.1}{4.0}$	$\frac{0.2}{8.0}$	$\frac{1.8}{14.}$	.	.	$\frac{0.4}{4.0}$	$\frac{5.9}{50.}$	$\frac{1.7}{38.}$	$\frac{0.3}{2.0}$	.
<u>Delphinium bicolor</u>	.	.	.	.	.	+	.	.	.	.
<u>Disporum trachycarpum</u>	.	.	.	.	.	.	.	.	+	+
<u>Epilobium angustifolium</u>	.	.	.	.	.	.	.	$\frac{1.0}{8.0}$	.	+

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Erigeron divergens</u>	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.
<u>Erigeron speciosus</u>	.	.	*	.	.	.	+	.	.	.
<u>Erigeron subtrinervis</u>	.	.	.	.	.	.	.	.	.	$\frac{0.1}{4.0}$
<u>Eriogonum subalpinum</u>	.	.	.	.	.	.	+	.	.	.
<u>Erysimum argillosum</u>	.	.	.	.	.	+	.	.	.	.
<u>Erysimum asperum</u>	.	.	.	.	.	.	+	+	.	.
<u>Fragaria virginiana</u>	.	.	.	.	.	.	.	.	.	$\frac{0.6}{24.}$
<u>Fritillaria atropurpurea</u>	.	.	.	.	+	.	.	.	.	.
<u>Galium aparine</u>	.	.	$\frac{0.3}{12.}$	.	.	.	$\frac{0.4}{4.0}$	.	.	.
<u>Galium boreale</u>	.	.	.	$\frac{0.3}{12.}$	$\frac{3.2}{48.}$	$\frac{0.2}{8.0}$	+	$\frac{1.7}{16.}$	$\frac{0.1}{2.0}$	$\frac{0.9}{34.}$
<u>Geranium viscosissimum</u>	$\frac{0.2}{4.0}$	$\frac{0.6}{4.0}$	.	.	$\frac{0.2}{8.0}$	.	.	.	.	.

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Glycyrrhiza lepidota</u>	+	.	.	.	.	.	.	.	.	.
<u>Goodyera oblongifolia</u>	.	.	.	.	.	.	.	.	+	.
<u>Heuchera parviflora</u>	.	.	.	.	.	$\frac{0.3}{14.}$	.	.	.	.
<u>Hymenoxys acaulis</u>	.	.	.	+	.	.	.	.	.	.
<u>Lesquerella alpina</u>	$\frac{0.1}{4.0}$	.	.	.	.	.	.	.	.	.
<u>Leucocrinum montanum</u>	$\frac{0.1}{4.0}$	.	.	.	.	.	.	.	.	.
Lichens + Mosses	+	+	$\frac{.65}{12.}$	$\frac{0.2}{8.0}$	$\frac{0.9}{10.}$	$\frac{1.1}{16.}$	$\frac{1.3}{18.}$	$\frac{1.3}{22.}$	$\frac{0.4}{6.0}$	$\frac{1.0}{18.}$
<u>Lithospermum incisum</u>	+	.	.	.	.	.	.	.	.	.
<u>Lomatium ambiguum</u>	.	.	.	$\frac{1.6}{36.}$	$\frac{0.4}{6.0}$	.	.	.	$\frac{0.1}{4.0}$	$\frac{0.7}{36.}$
<u>Lomatium dissectum</u>	.	.	.	.	$\frac{2.3}{20.}$	.	.	.	.	.
<u>Lupinus argenteus</u>	.	.	.	.	+	$\frac{6.9}{54.}$	$\frac{3.4}{20.}$	$\frac{4.1}{18.}$	.	+

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Lycopodium obscurum</u>	.	$\frac{0.6}{4.0}$	.	.	.	.	.	.	.	.
<u>Mahonia repens</u>	.	.	.	.	$\frac{1.2}{28.}$	.	.	$\frac{5.9}{30.}$	.	$\frac{4.8}{42.}$
<u>Monarda fistulosa</u>	.	$\frac{0.3}{12.}$	.	.	.	.	+	.	.	.
<u>Montia perfoliata</u>	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.
<u>Musineon vaginatum</u>	.	.	.	.	.	.	.	+	.	.
<u>Opuntia polyacantha</u>	$\frac{0.4}{6.0}$	.	.	.	.	.	.	.	.	.
<u>Penstemon procera</u>	.	.	.	.	+	.	.	.	.	.
<u>Phlox multiflora</u>	.	.	.	$\frac{0.2}{10.}$	.	.	.	.	.	.
<u>Polygonum bistortoides</u>	.	.	.	.	.	$\frac{0.1}{4.0}$	.	+	.	+
<u>Potentilla diffusa</u>	.	.	.	+	.	.	.	.	.	.
<u>Potentilla fissa</u>	.	.	.	.	.	$\frac{1.1}{16.}$	.	.	.	.

Table B, cont'd.

Stand Number	2	5	7	62	3	63	6	8	9	79
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Rosa acicularis</u>	.	$\frac{0.6}{4.0}$	+	.	.	.	.	+	.	$\frac{1.5}{10.}$
<u>Sedum lanceolatum</u>	+	.	+	.	.	$\frac{0.2}{6.0}$	.	.	.	.
<u>Senecio streptanthifolius</u>	.	.	.	.	.	+	.	$\frac{0.1}{10.}$	.	*
<u>Smilacina racemosa</u>	.	.	+	.	$\frac{14.}{68.}$	.	.	.	$\frac{0.4}{6.0}$	$\frac{0.8}{14.}$
<u>Spiraea betulifolia</u>	.	.	+	.	$\frac{5.8}{48.}$	$\frac{5.3}{38.}$	*	$\frac{16.}{70.}$	$\frac{14.}{56.}$	$\frac{9.3}{78.}$
<u>Symphoricarpos albus</u>	.	$\frac{8.6}{52.}$	.	.	$\frac{1.2}{16.}$	$\frac{18.}{90.}$	.	$\frac{4.5}{42.}$	$\frac{3.3}{24.}$	$\frac{11.}{80.}$
<u>Taraxacum sp.</u>	.	.	$\frac{0.8}{22.}$	.	.	$\frac{0.4}{6.0}$	.	.	.	.
<u>Toxicodendron rydbergii</u>	.	.	.	.	$\frac{0.2}{6.0}$	.	.	.	.	.
<u>Viola nuttallii</u>	$\frac{0.6}{14.}$	.	.	.	.	.	.	.	.	.
<u>Yucca glauca</u>	$\frac{0.1}{4.0}$	.	.	.	.	.	.	.	.	.
<u>Zigadenus elegans</u>	.	.	.	.	.	$\frac{0.5}{8.0}$	.	$\frac{0.3}{4.0}$	$\frac{0.1}{4.0}$	.

Table C. Undergrowth data of Pseudotsuga menziesii dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but not in any microplot are indicated by \*. Other data included are stand location and topographic position.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
Location:													
Section	33	19	28	30	24	18	26	11	13	25	12	22	22
Township	48N	48N	54N	56N	48N	48N	49N	49N	48N	49N	53N	56N	56N
Range	83W	83W	85W	92W	87W	86W	87W	87W	87W	87W	90W	87W	87W
Topographic Position:													
Slope	3°	5°	16°	5°	25°	23°	24°	26°	23°	15°	24°	20°	20°
Aspect	215°	75°	85°	179°	274°	255°	215°	205°	65°	180°	310°	50°	50°
Elevation, meters	2286	2365	2240	2256	2158	2207	2573	2591	2207	2609	1878	1981	2012
% Coverage	C	C	C	C	C	C	C	C	C	C	C	C	C
% Frequency	F	F	F	F	F	F	F	F	F	F	F	F	F

#### LARGE SHRUBS

<u>Acer glabrum</u>	.	.	.	.	$\frac{2.0}{2.0}$	.	.	.	.	.	.	.	.
<u>Artemisia tridentata</u>	.	.	.	.	.	.	.	.	$\frac{0.3}{2.0}$	.	.	.	.
<u>Ceanothus velutinus</u>	.	.	.	.	.	.	.	.	+	.	.	.	.
<u>Juniperus communis</u>	+	$\frac{48.}{37.}$	+	$\frac{2.4}{4.0}$	.	$\frac{0.1}{4.0}$	$\frac{7.0}{14.}$	$\frac{13.}{34.}$	$\frac{1.7}{2.0}$	$\frac{0.6}{4.0}$	.	$\frac{4.2}{10.}$	$\frac{5.1}{14.}$
<u>Juniperus osteosperma</u>	.	.	.	+	.	.	.	.	.	+	.	.	.
<u>Juniperus scopulorum</u>	.	.	.	.	.	.	.	.	.	.	*	$\frac{0.3}{2.0}$	+
<u>Physocarpus monogynus</u>	.	.	.	.	.	.	.	.	.	.	$\frac{28.}{100}$	$\frac{25.}{72.}$	$\frac{23.}{76.}$
<u>Ribes cereum</u>	.	+	.	.	.	.	.	.	.	.	.	.	.

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Ribes lacustre</u>	.	*	+	.	$\frac{0.1}{4.0}$	$\frac{0.8}{6.0}$	$\frac{0.8}{4.0}$	$\frac{1.1}{6.0}$	$\frac{0.3}{4.0}$	.	.	.	.
<u>Ribes montigenum</u>	.	.	.	.	.	.	.	.	.	$\frac{0.4}{8.0}$	.	.	.
<u>Shepherdia canadensis</u>	.	.	.	.	.	.	.	.	.	.	.	$\frac{0.6}{4.0}$	.
GRAMINOIDS													
<u>Agropyron spicatum</u>	.	.	.	.	.	.	.	.	$\frac{0.4}{8.0}$	.	.	.	.
<u>Carex brevipes</u>	.	.	.	.	.	$\frac{0.2}{6.0}$	.	.	$\frac{0.1}{2.0}$	.	.	.	.
<u>Carex vallicola</u>	.	.	.	.	.	.	.	.	+	.	.	.	.
<u>Festuca idahoensis</u>	$\frac{0.3}{10.}$	.	.	.	.	.	+	.	$\frac{1.4}{10.}$	.	.	.	.
<u>Festuca ovina</u>	$\frac{0.5}{10.}$	+	.	.	.	+	.	.	.	.	.	.	.
<u>Hesperochloa kingii</u>	$\frac{1.7}{18.}$	.	.	+	+	.	+	$\frac{0.9}{18.}$	$\frac{1.8}{20.}$	$\frac{1.2}{16.}$	.	$\frac{0.3}{2.0}$	.
<u>Koeleria cristata</u>	.	.	.	.	.	.	+	.	$\frac{7.0}{40.}$	.	+	.	.

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Poa canbyi</u>	.	.	.	.	.	.	.	.	$\frac{0.1}{2.0}$	.	+	.	.
<u>Poa columbiana</u>	.	.	.	.	+	.	.	.	.	.	.	.	.
<u>Poa fendleriana</u>	.	.	.	.	.	$\frac{0.1}{2.0}$	.	.	.	.	.	.	.
<u>Poa interior</u>	.	$\frac{0.2}{8.0}$	.	.	.	.	.	$\frac{0.1}{4.0}$	.	$\frac{0.1}{4.0}$	$\frac{1.2}{10.}$	.	+
<u>Poa nervosa</u>	$\frac{0.4}{6.0}$	+	$\frac{0.6}{26.}$	.	$\frac{0.4}{6.0}$	$\frac{1.0}{20.}$	$\frac{0.4}{14.}$	.	.	$\frac{0.4}{14.}$	.	.	$\frac{0.1}{4.0}$
<u>Poa scabrella</u>	.	.	.	.	.	$\frac{1.7}{10.}$	.	.	+	.	.	+	.
<u>Stipa comata</u>	+	.	.	.	.	.	.	.	$\frac{0.5}{5.0}$	.	.	.	.
<u>Trisetum spicatum</u>	.	.	.	.	.	.	.	.	.	.	+	.	$\frac{0.6}{12.}$
LOW SHRUBS AND HERBS													
<u>Achillea millefolium</u>	$\frac{0.4}{14.}$	+	$\frac{0.1}{4.0}$	.	.	.	.	$\frac{0.7}{8.0}$	.	.	.	$\frac{0.1}{4.0}$	.
<u>Agoseris glauca</u>	.	$\frac{0.1}{4.0}$	.	.	.	.	.	.	.	.	.	.	.
<u>Allium cernuum</u>	.	.	$\frac{0.3}{2.0}$	+	.	.	.	.	.	.	.	.	.

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Anemone multifida</u>	.	$\frac{0.3}{10.}$	+	.	.	.	$\frac{0.1}{4.0}$	+	.	.	.	$\frac{0.5}{20.}$	$\frac{0.6}{14.}$
<u>Antennaria parviflora</u>	$\frac{0.2}{8.0}$	.	.	.	.	.	.	.	.	.	.	.	.
<u>Antennaria racemosa</u>	.	.	.	.	.	.	.	+	+	.	.	.	$\frac{0.4}{4.0}$
<u>Antennaria rosea</u>	+	$\frac{0.3}{2.0}$	.	.	.	.	.	.	.	.	.	.	.
<u>Arabis nuttallii</u>	.	.	.	.	.	.	+	.	+	.	.	.	.
<u>Arctostaphylos uva-ursi</u>	.	.	.	.	.	.	.	+	.	.	.	+	$\frac{0.1}{4.0}$
<u>Arenaria congesta</u>	$\frac{0.4}{8.0}$	.	.	.	.	.	.	$\frac{0.3}{4.0}$	+	.	.	$\frac{0.1}{4.0}$	.
<u>Arnica cordifolia</u>	.	$\frac{0.9}{24.}$	$\frac{32.}{90.}$	.	$\frac{5.7}{62.}$	$\frac{7.5}{54.}$	$\frac{6.6}{56.}$	$\frac{9.8}{46.}$	$\frac{0.2}{8.0}$	$\frac{35.}{94.}$	.	$\frac{4.0}{34.}$	$\frac{0.5}{20.}$
<u>Aster foliaceus</u>	.	+	.	.	+	+	.	.	.	.	+	.	.
<u>Astragalus miser</u>	$\frac{12.}{36.}$	.	.	.	.	.	.	$\frac{0.4}{6.0}$	.	+	.	.	.
<u>Balsamorhiza sagittata</u>	.	.	.	.	.	.	.	.	$\frac{0.2}{8.0}$	.	.	$\frac{3.2}{12.}$	$\frac{2.3}{8.0}$

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Castilleja gracillima</u>	.	.	.	.	.	.	.	.	.	.	+	+	+
<u>Cerastium arvense</u>	.	+	.	.	.	.	.	.	$\frac{0.2}{6.0}$	.	.	.	.
<u>Clematis tenuiloba</u>	.	$\frac{0.4}{4.0}$	.	.	+	.	.	.	.	.	.	$\frac{1.2}{16.}$	$\frac{0.7}{18.}$
<u>Cystopteris fragilis</u>	.	.	.	.	+	.	.	.	+	.	.	.	.
<u>Disporum trachycarpum</u>	.	.	$\frac{1.0}{10.}$	+	.	$\frac{0.3}{2.0}$	.	.	.	.	.	.	.
<u>Erigeron sp.</u>	.	+	.	.	+	.	+	.	.	.	+	.	.
<u>Epilobium angustifolium</u>	$\frac{0.2}{6.0}$	.	+	+	.	+	.	+	.	+	+	.	+
<u>Erysimum asperum</u>	.	.	.	.	.	.	.	.	+	.	.	.	.
<u>Fragaria virginiana</u>	.	.	$\frac{0.4}{14.}$	.	.	.	$\frac{0.2}{8.0}$	$\frac{0.4}{14.}$	.	.	.	.	.
<u>Galium boreale</u>	$\frac{0.4}{4.0}$	$\frac{1.1}{34.}$	$\frac{6.8}{80.}$	.	.	$\frac{0.6}{14.}$	$\frac{0.6}{12.}$	+	.	$\frac{0.7}{16.}$	.	$\frac{0.6}{22.}$	$\frac{1.4}{24.}$
<u>Gentiana amarella</u>	.	.	.	.	.	.	.	.	.	$\frac{0.5}{10.}$	.	.	+

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Geranium viscosissimum</u>	*	.	.	.	.	+	.	.	.	.	.	.	.
<u>Geum triflorum</u>	.	.	.	.	+	.	.	.	.	+	.	.	.
<u>Glycyrrhiza lepidota</u>	.	.	.	.	.	.	.	.	+	.	.	.	.
<u>Hedysarum sulphurescens</u>	$\frac{0.3}{2.0}$	.	.	.	.	.	.	.	.	.	.	$\frac{0.4}{4.0}$	+
<u>Heuchera parviflora</u>	.	.	.	.	$\frac{0.1}{4.0}$	.	$\frac{0.1}{4.0}$	.	.	.	.	.	.
Lichens + Mosses	$\frac{2.0}{30.}$	$\frac{2.8}{34.}$	$\frac{0.1}{5.0}$	$\frac{0.1}{4.0}$	$\frac{0.4}{6.0}$	$\frac{0.8}{20.}$	$\frac{1.5}{10.}$	$\frac{0.1}{4.0}$	$\frac{0.1}{4.0}$	$\frac{1.0}{10.}$	$\frac{17.}{95.}$	$\frac{0.5}{8.0}$	$\frac{1.4}{16.}$
<u>Lomatium dissectum</u>	.	.	+	.	.	.	.	.	.	.	.	$\frac{0.3}{12.}$	$\frac{1.4}{16.}$
<u>Lupinus argenteus</u>	$\frac{5.0}{14.}$	.	.	.	.	.	.	.	.	$\frac{0.5}{10.}$	.	.	.
<u>Lupinus monticola</u>	.	.	.	.	.	.	.	$\frac{1.7}{10.}$	.	.	.	.	.
<u>Mahonia repens</u>	.	$\frac{0.1}{4.0}$	$\frac{8.0}{48.}$	$\frac{12.}{72.}$	$\frac{28.}{86.}$	$\frac{11.}{50.}$	$\frac{6.1}{50.}$	$\frac{5.0}{42.}$	$\frac{2.0}{12.}$	$\frac{1.4}{26.}$	$\frac{1.3}{20.}$	.	$\frac{0.9}{14.}$
<u>Mertensia ciliata</u>	.	.	$\frac{1.2}{20.}$	.	.	.	.	.	.	.	.	.	.

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Mitella pentandra</u>	.	.	.	.	.	.	.	.	.	+	$\frac{0.2}{12.}$	.	.
<u>Musineon vaginatum</u>	.	.	.	.	.	.	.	.	.	.	.	.	+
<u>Osmorhiza depauperata</u>	.	.	$\frac{5.4}{46.}$	.	.	.	.	.	.	.	.	.	.
<u>Penstemon aridis</u>	.	.	.	.	.	.	.	$\frac{0.6}{4.0}$	.	.	.	.	.
<u>Phlox multiflora</u>	+	+	.	.	.	.	.	.	+	.	.	.	+
<u>Polygonum bistortoides</u>	.	.	.	.	.	.	.	.	.	.	.	+	.
<u>Potentilla diversifolia</u>	.	$\frac{0.1}{4.0}$	.	.	.	.	+	.	.	.	.	.	.
<u>Potentilla fissa</u>	.	$\frac{0.3}{10.}$	.	.	.	.	.	.	.	.	.	.	.
<u>Rosa acicularis</u>	.	$\frac{0.9}{16.}$	.	+	.	.	.	$\frac{0.2}{8.0}$	.	.	$\frac{0.4}{8.0}$	+	$\frac{0.6}{14.}$
<u>Sedum lanceolatum</u>	+	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.	+	.
<u>Senecio integerrimus</u>	.	.	.	.	+	$\frac{0.3}{2.0}$	.	$\frac{1.2}{16.}$	.	.	.	.	.

Table C, cont'd.

Stand Number	16	64	26	78	11	12	13	14	15	68	77	20	70
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Senecio streptanthifolius</u>	.	$\frac{0.2}{8.0}$	.	.	$\frac{0.2}{6.0}$	$\frac{2.1}{16.}$	$\frac{0.9}{16.}$	$\frac{1.8}{22.}$	$\frac{2.3}{22.}$	+	.	.	.
<u>Silene menziesii</u>	.	.	.	.	.	.	.	.	+	.	.	$\frac{0.1}{4.0}$	.
<u>Smilacina racemosa</u>	.	.	$\frac{1.5}{18.}$	+	$\frac{2.0}{20.}$	$\frac{0.7}{18.}$	.	$\frac{0.8}{10.}$	.	.	.	.	+
<u>Solidago missouriensis</u>	.	.	.	.	.	.	.	.	.	.	+	.	.
<u>Spiraea betulifolia</u>	.	.	$\frac{13.}{62.}$	.	.	.	.	.	.	.	.	$\frac{6.6}{50.}$	$\frac{3.9}{48.}$
<u>Symphoricarpos oreophilus</u>	.	$\frac{0.1}{4.0}$	$\frac{0.4}{4.0}$	$\frac{0.2}{6.0}$	$\frac{0.8}{4.0}$	$\frac{1.2}{2.0}$	.	.	$\frac{14.}{34.}$	.	$\frac{0.2}{12.}$	$\frac{8.2}{56.}$	$\frac{10.}{70.}$
<u>Taraxacum sp.</u>	.	+	$\frac{0.9}{16.}$	.	.	.	.	.	.	.	.	.	.
<u>Thalictrum occidentale</u>	.	.	$\frac{14.}{56.}$	.	.	.	.	.	.	.	.	.	.
<u>Valeriana dioica</u>	.	.	.	.	.	.	$\frac{0.3}{4.0}$	.	.	.	.	.	.
<u>Viola adunca</u>	.	+	.	.	+	.	.	.	.	.	.	.	.
<u>Zigadenus elegans</u>	.	.	.	.	.	.	.	.	.	.	.	+	$\frac{0.6}{22.}$

Table D. Undergrowth data of Populus tremuloides dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but no in any microplot are indicated by \*. Other data included are stand location and topographic position.

Stand Number	61	19	17	10
Location:				
Section	11	36	13	24
Township	50N	49N	48N	48N
Range	84W	84W	84W	87W
Topographic Position:				
Slope	--	10°	--	3°
Aspect	--	115°	--	300°
Elevation, meters	2225	2365	2353	2140
% Coverage	C	C	C	C
% Frequency	F	F	F	F

#### LARGE SHRUBS

<u>Artemisia tridentata</u>	.	.	.	$\frac{0.6}{6.0}$
<u>Juniperus communis</u>	$\frac{4.8}{10.}$	.	.	*
<u>Juniperus osteosperma</u>	.	.	.	+
<u>Ribes cereum</u>	.	+	.	$\frac{0.8}{2.0}$
<u>Ribes lacustre</u>	+	$\frac{3.7}{16.}$	.	.
<u>Salix bebbiana</u>	$\frac{0.8}{10.}$	.	.	.

#### GRAMINOIDS

<u>Agropyron dasystachyum</u>	$\frac{0.6}{4.0}$	$\frac{0.2}{8.0}$	$\frac{0.8}{20.}$	.
<u>Agropyron spicatum</u>	+	$\frac{4.6}{40.}$	+	$\frac{8.0}{30.}$
<u>Carex phaeocephala</u>	$\frac{0.2}{8.0}$	$\frac{0.2}{8.0}$	.	.
<u>Carex platylepis</u>	.	$\frac{0.5}{2.0}$	$\frac{2.4}{30.}$	$\frac{1.6}{32.}$

Table D, cont'd.

Stand Number	61	19	17	10
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Carex scopulorum</u>	$\frac{0.2}{4.0}$	+	$\frac{3.0}{24.}$	$\frac{2.0}{8.0}$
<u>Dactylis glomerata</u>	+	.	+	+
<u>Festuca idahoensis</u>	$\frac{2.0}{20.}$	$\frac{4.2}{8.0}$	$\frac{0.6}{10.}$	$\frac{15.}{40.}$
<u>Hesperochloa kingii</u>	$\frac{1.2}{10.}$	$\frac{2.3}{16.}$	$\frac{0.1}{4.0}$	$\frac{2.0}{15.}$
<u>Phleum pratense</u>	+	$\frac{2.0}{20.}$	$\frac{3.6}{40.}$	$\frac{1.0}{18.}$
<u>Poa nervosa</u>	$\frac{1.6}{22.}$	$\frac{5.0}{36.}$	$\frac{4.0}{40.}$	$\frac{1.6}{28.}$
LOW SHRUBS AND HERBS				
<u>Achillea millefolium</u>	$\frac{3.0}{64.}$	$\frac{5.0}{60.}$	$\frac{1.1}{24.}$	$\frac{0.4}{6.0}$
<u>Allium brevistylum</u>	+	.	$\frac{0.1}{4.0}$	.
<u>Anemone multifida</u>	$\frac{0.8}{22.}$	$\frac{1.6}{24.}$	$\frac{3.6}{28.}$	.
<u>Antennaria rosea</u>	+	$\frac{0.1}{4.0}$	.	$\frac{0.1}{4.0}$
<u>Arctostaphylos uva-ursi</u>	+	.	.	.
<u>Arnica fulgens</u>	.	.	+	.
<u>Astragalus alpinus</u>	.	$\frac{1.6}{8.0}$	$\frac{12.}{20.}$	.
<u>Cerastium arvense</u>	.	$\frac{0.1}{4.0}$	+	+
<u>Clematis tenuiloba</u>	.	.	.	+

Table D, cont'd.

Stand Number	61	19	17	10
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Fragaria virginiana</u>	$\frac{4.0}{40.}$	$\frac{5.1}{48.}$	$\frac{3.8}{52.}$	.
<u>Galium boreale</u>	$\frac{0.8}{30.}$	$\frac{5.6}{48.}$	+	.
<u>Geranium fremontii</u>	.	.	+	.
<u>Lupinus argenteus</u>	.	$\frac{10.}{40.}$	$\frac{18.}{30.}$	$\frac{7.0}{38.}$
<u>Lupinus wyethii</u>	.	$\frac{2.0}{8.0}$	$\frac{20.}{40.}$	$\frac{6.0}{20.}$
<u>Mahonia repens</u>	.	.	.	$\frac{1.6}{22.}$
<u>Osmorhiza depauperata</u>	+	$\frac{2.0}{10.}$	.	.
<u>Oxytropus campestris</u>	$\frac{0.8}{14.}$	.	+	.
<u>Polygonum bistortoides</u>	$\frac{0.2}{8.0}$	.	+	.
<u>Potentilla diversifolia</u>	$\frac{3.0}{48.}$	.	$\frac{1.0}{20.}$	.
<u>Potentilla fissa</u>	.	.	+	.
<u>Potentilla fruticosa</u>	$\frac{1.6}{10.}$	$\frac{0.8}{12.}$	.	.
<u>Potentilla gracilis</u>	.	+	.	.
<u>Primula parryi</u>	+	.	.	.
<u>Rosa acicularis</u>	$\frac{1.1}{22.}$	.	$\frac{0.2}{8.0}$	.

Table D, cont'd.

Stand Number	61	19	17	10
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Sedum lanceolatum</u>	.	.	.	+
<u>Taraxacum officinale</u>	$\frac{13.}{74.}$	$\frac{33.}{96.}$	$\frac{22.}{100}$	$\frac{12.}{90.}$
<u>Thalictrum occidentale</u>	.	.	.	$\frac{0.2}{8.0}$
<u>Trifolium sp.</u>	$\frac{26.}{90.}$	$\frac{2.6}{42.}$	.	$\frac{4.4}{50.}$
<u>Viola adunca</u>	$\frac{0.1}{4.0}$	.	.	.
<u>Zigadenus elegans</u>	+	.	.	.

Table E. Undergrowth data of Pinus contorta dominated forests include coverage (C) and frequency (F). Species having a coverage of less than 0.1% are indicated by +. Species present in the stand but not in any microplot are indicated by \*. Other data included are stand location and topographic position.

Stand Number	47	50	51	83	84	53	85	69	67	60	58	54	49	46	45	25
Location:																
Section	27	23	36	2	3	7	11	32	2	34	4	6	14	27	3	25
Township	50N	49N	49N	49N	49N	48N	49N	49N	50N	55N	53N	48N	49N	55N	53N	54N
Range	84W	84W	84W	84W	84W	84W	84W	86W	88W	88W	86W	84W	84W	88W	86W	86W
Topographic																
Position:																
Slope	6°	4°	14°	5°	5°	10°	4°	10°	4°	0°	19°	10°	8°	0°	10°	12°
Aspect	26°	70°	35°	170°	58°	165°	305°	285°	265°	---	357°	12°	15°	---	345°	45°
Elevation, m	2399	2512	2390	2463	2432	2569	2512	2499	2640	2560	2380	2603	2560	2560	2353	2341
% Coverage	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
% Frequency	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F

#### LARGE SHRUBS

<u>Juniperus communis</u>	$\frac{2.1}{10.}$	$\frac{9.2}{26.}$	$\frac{7.4}{38.}$	$\frac{0.1}{4.0}$	$\frac{8.4}{22.}$	$\frac{14.}{26.}$	$\frac{17.}{50.}$	.	$\frac{0.8}{4.0}$	$\frac{1.1}{6.0}$	$\frac{0.8}{4.0}$	.	$\frac{8.2}{24.}$	$\frac{0.3}{2.0}$	.	.
<u>Ribes lacustre</u>	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
<u>Shepherdia canadensis</u>	+	.	$\frac{0.6}{4.0}$	.	.	.	.	.	.	.	.	.	.	.	.	.

#### GRAMINOIDS

<u>Carex brevipes</u>	.	+	.	.	+	.	$\frac{0.6}{12.}$	.	.	.	+	.	.	+	.	.
<u>Carex geyeri</u>	.	.	.	.	.	+	.	.	+	.	.	.	.	.	+	.
<u>Festuca idahoensis</u>	.	.	.	.	.	.	.	.	.	$\frac{0.2}{4.0}$	.	.	.	+	.	.

Table E, cont'd.

Stand Number	47	50	51	83	84	53	85	69	67	60	58	54	49	46	45	25
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Festuca ovina</u>	$\frac{0.1}{4.0}$	$\frac{0.8}{18.}$	.	$\frac{0.2}{8.0}$	.	$\frac{0.6}{14.}$	$\frac{0.6}{10.}$	$\frac{6.0}{30.}$	.	.	$\frac{0.2}{4.0}$	.	$\frac{0.4}{10.}$	$\frac{1.0}{10.}$	.	$\frac{0.4}{6.0}$
<u>Koeleria cristata</u>	.	.	.	.	.	.	.	.	$\frac{0.2}{4.0}$	.	.	.	.	.	.	.
<u>Poa canbyi</u>	.	.	.	.	.	.	.	+	$\frac{0.2}{4.0}$	.	.	+	.	+	.	.
<u>Poa interior</u>	.	.	$\frac{0.2}{4.0}$	.	.	.	$\frac{0.2}{4.0}$	$\frac{1.0}{14.}$	$\frac{0.6}{12.}$	$\frac{0.6}{12.}$	+	$\frac{0.2}{6.0}$	.	$\frac{1.8}{18.}$	+	$\frac{0.2}{4.0}$
<u>Poa nervosa</u>	.	.	.	.	$\frac{0.2}{8.0}$	.	.	$\frac{4.8}{26.}$	$\frac{0.6}{14.}$	$\frac{0.6}{10.}$	.	$\frac{0.2}{4.0}$	$\frac{0.2}{6.0}$	$\frac{2.2}{14.}$	$\frac{0.3}{12.}$	$\frac{1.6}{24.}$
<u>Trisetum spicatum</u>	$\frac{0.1}{4.0}$	$\frac{0.4}{10.}$	$\frac{0.4}{12.}$	.	.	$\frac{0.4}{6.0}$	$\frac{0.2}{6.0}$	$\frac{0.4}{6.0}$	.	$\frac{0.4}{10.}$	$\frac{0.2}{4.0}$	.	.	$\frac{2.0}{20.}$	+	+
LOW SHRUBS AND HERBS																
<u>Achillea millefolium</u>	.	$\frac{0.1}{4.0}$	.	$\frac{0.1}{4.0}$	.	.	+	+	.	$\frac{1.2}{38.}$	+	+	+	$\frac{0.1}{4.0}$	.	.
<u>Agoseris glauca</u>	.	.	.	.	.	.	.	.	$\frac{0.1}{6.0}$	.	.	.	.	.	.	.
<u>Allium brevistylum</u>	.	.	.	.	.	.	.	+	$\frac{0.1}{6.0}$	+	.	.	.	.	.	.
<u>Antennaria neglecta</u>	.	.	$\frac{0.1}{6.0}$	.	.	.	.	.	.	.	.	.	.	.	.	.
<u>Antennaria racemosa</u>	.	.	$\frac{0.1}{4.0}$	$\frac{0.2}{8.0}$	.	.	.	.	.	$\frac{0.2}{8.0}$	$\frac{0.9}{28.}$	.	.	.	$\frac{2.8}{36.}$	$\frac{1.0}{20.}$

Table E, cont'd.

Stand Number	47	50	51	83	84	53	85	69	67	60	58	54	49	46	45	25
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Antennaria rosea</u>	.	$\frac{2.2}{26.}$	$\frac{0.4}{6.0}$	+	+	$\frac{1.4}{16.}$	$\frac{0.3}{4.0}$	.	.	$\frac{0.1}{6.0}$	.	$\frac{0.4}{8.0}$	$\frac{0.2}{6.0}$	+	$\frac{0.7}{8.0}$	.
<u>Antennaria umbrinella</u>	$\frac{1.0}{10.}$	.	.	.	.	.	.	.	.	.	.	.	+	+	.	$\frac{0.3}{2.0}$
<u>Arctostaphylos</u> <u>uva-ursi</u>	$\frac{17.}{60.}$	$\frac{14.}{40.}$	$\frac{15.}{56.}$	$\frac{2.7}{12.}$	$\frac{17.}{46.}$	+	$\frac{1.1}{6.0}$	.	.	.	+	.	.	.	.	.
<u>Arenaria congesta</u>	.	+	.	.	.	.	.	$\frac{0.2}{8.0}$	+	.	.	.	.	+	.	.
<u>Arnica cordifolia</u>	+	.	$\frac{0.6}{14.}$	$\frac{0.4}{16.}$	$\frac{0.1}{4.0}$	+	+	$\frac{9.0}{70.}$	$\frac{11.}{62.}$	$\frac{3.6}{36.}$	$\frac{0.9}{26.}$	$\frac{0.6}{24.}$	.	$\frac{2.5}{50.}$	$\frac{2.5}{42.}$	$\frac{0.3}{12.}$
<u>Arnica latifolia</u>	.	.	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.	.	$\frac{0.4}{16.}$	.	.
<u>Aster foliaceus</u>	.	.	.	$\frac{0.3}{12.}$	.	.	.	.	.	.	.	.	.	.	+	.
<u>Campanula</u> <u>rotundifolia</u>	+	+	+	+	.	+	+	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.
<u>Chimaphila umbellata</u>	.	.	.	.	.	.	.	.	.	.	+	.	.	.	.	.
<u>Delphinium bicolor</u>	.	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<u>Epilobium</u> <u>angustifolium</u>	+	.	.	$\frac{0.1}{4.0}$	.	.	$\frac{0.1}{4.0}$	.	$\frac{0.7}{30.}$	$\frac{0.6}{24.}$	+	$\frac{0.1}{4.0}$	+	$\frac{0.2}{8.0}$	$\frac{0.8}{22.}$	.

Table E, cont'd.

Stand Number	47	50	51	83	84	53	85	69	67	60	58	54	49	46	45	25
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Fragaria virginiana</u>	.	.	.	$\frac{0.5}{20.}$	.	.	.	$\frac{0.9}{18.}$	$\frac{1.0}{20.}$	.	.	+	.	.	$\frac{0.7}{6.0}$	.
<u>Galium boreale</u>	.	.	.	$\frac{0.2}{8.0}$	.	.	.	.	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.
<u>Gentiana amarella</u>	$\frac{0.3}{2.0}$	.	$\frac{0.1}{4.0}$	.	.	.	.	.	.	+	.	.	.	.	.	.
<u>Hieracium albiflorum</u>	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.	.
<u>Hieracium gracile</u>	.	.	.	.	.	.	.	.	.	$\frac{0.2}{8.0}$	$\frac{0.6}{24.}$	$\frac{0.2}{10.}$	$\frac{0.1}{4.0}$	.	.	.
<u>Kalmia polifolia</u>	.	.	+	.	.	.	.	.	.	.	.	.	.	+	$\frac{0.4}{18.}$	.
Lichens + Mosses	$\frac{2.9}{22.}$	$\frac{2.4}{24.}$	$\frac{12.}{56.}$	$\frac{1.7}{20.}$	$\frac{4.8}{42.}$	$\frac{1.5}{18.}$	$\frac{6.4}{38.}$	$\frac{3.2}{40.}$	$\frac{2.8}{32.}$	$\frac{2.4}{24.}$	$\frac{0.8}{20.}$	$\frac{0.4}{4.0}$	$\frac{4.8}{32.}$	$\frac{0.8}{10.}$	$\frac{0.2}{6.0}$	$\frac{0.1}{4.0}$
<u>Linnaea borealis</u>	$\frac{8.0}{54.}$	.	+	.	.	.	.	.	.	.	.	.	.	.	.	.
<u>Lupinus argenteus</u>	$\frac{3.8}{46.}$	$\frac{12.}{60.}$	$\frac{7.2}{50.}$	$\frac{1.6}{24.}$	$\frac{4.8}{30.}$	$\frac{15.}{48.}$	$\frac{5.0}{76.}$	$\frac{0.1}{4.0}$	$\frac{1.7}{18.}$	$\frac{16.}{74.}$	$\frac{8.4}{42.}$	$\frac{0.7}{10.}$	$\frac{11.}{72.}$	$\frac{7.6}{46.}$	$\frac{8.2}{56.}$	$\frac{0.9}{26.}$
<u>Mahonia repens</u>	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	$\frac{0.2}{8.0}$
<u>Osmorhiza chilensis</u>	.	.	.	.	.	.	.	+	$\frac{0.1}{4.0}$	+	.	.	.	.	.	.

Table E, cont'd.

Stand Number	47	50	51	83	84	53	85	69	67	60	58	54	49	46	45	25
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Pedicularis racemosa</u>	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<u>Penstemon rydbergii</u>	.	+	+	.	.	.	+	$\frac{0.8}{14.}$	.	.	.	.	.	+	.	.
<u>Potentilla diversifolia</u>	.	.	.	$\frac{0.1}{4.0}$	.	+	.	$\frac{3.1}{46.}$	$\frac{0.5}{10.}$	$\frac{0.2}{8.0}$	.	+	.	$\frac{0.6}{14.}$	$\frac{0.2}{6.0}$	.
<u>Potentilla fissa</u>	.	.	.	*	.	.	.	.	.	.	.	.	.	.	.	.
<u>Pyrola secunda</u>	$\frac{0.4}{6.0}$	.	.	.	.	+	$\frac{1.0}{22.}$	.	.	.	$\frac{0.1}{4.0}$	.	$\frac{0.2}{8.0}$	.	.	$\frac{0.8}{4.0}$
<u>Pyrola virens</u>	+	.	+	.	+	.	$\frac{0.8}{14.}$	.	.	.	.	.	.	.	.	.
<u>Rosa acicularis</u>	$\frac{0.3}{12.}$	.	+	.	$\frac{0.2}{6.0}$	+	$\frac{0.1}{4.0}$	$\frac{1.0}{12.}$	$\frac{0.6}{12.}$	.	$\frac{0.2}{10.}$	.	$\frac{0.2}{6.0}$	.	.	.
<u>Saxifraga odontiloma</u>	.	.	.	.	.	.	.	.	.	.	.	.	.	+	.	.
<u>Sedum lanceolatum</u>	+	+	.	.	.	.	.	.	.	.	.	.	.	.	.	.
<u>Senecio streptanthifolius</u>	$\frac{0.2}{8.0}$	$\frac{0.6}{24.}$	$\frac{0.4}{12.}$	$\frac{3.2}{48.}$	$\frac{0.5}{10.}$	$\frac{0.6}{12.}$	$\frac{0.4}{14.}$	$\frac{0.4}{6.0}$	$\frac{0.1}{4.0}$	$\frac{3.3}{70.}$	$\frac{0.1}{4.0}$	$\frac{1.9}{38.}$	$\frac{0.7}{28.}$	$\frac{0.4}{14.}$	+	$\frac{0.5}{12.}$
<u>Silene menziesii</u>	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.

Table E, cont'd.

Stand Number	47	50	51	83	84	53	85	69	67	60	58	54	49	46	45	25
% Coverage % Frequency	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$	$\frac{C}{F}$
<u>Solidago multiradiata</u>	.	.	.	.	.	.	.	.	.	+	.	.	.	+	.	.
<u>Solidago spatulata</u>	.	$\frac{0.2}{4.0}$	$\frac{0.4}{16.}$	$\frac{1.5}{40.}$	$\frac{0.2}{8.0}$	.	$\frac{0.4}{8.0}$	.	.	.	.	+	.	.	+	$\frac{1.0}{20.}$
<u>Spiraea betulifolia</u>	$\frac{1.5}{38.}$	.	+	$\frac{3.0}{40.}$	$\frac{0.8}{24.}$	.	.	.	.	.	$\frac{2.0}{60.}$	.	.	.	.	$\frac{4.1}{44.}$
<u>Taraxacum sp.</u>	.	.	.	.	.	.	.	+	.	.	.	.	.	.	+	.
<u>Vaccinium scoparium</u>	$\frac{1.5}{18.}$	.	$\frac{2.2}{20.}$	.	$\frac{1.7}{10.}$	*	$\frac{36.}{92.}$	$\frac{27.}{64.}$	$\frac{69.}{98.}$	$\frac{31.}{46.}$	$\frac{67.}{100}$	$\frac{30.}{84.}$	$\frac{9.1}{22.}$	$\frac{25.}{64.}$	$\frac{50.}{100}$	$\frac{31.}{70.}$
<u>Valeriana dioica</u>	.	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.
<u>Viola adunca</u>	.	.	.	.	.	.	.	$\frac{0.1}{4.0}$	.	.	.	.	.	.	.	.
<u>Zigadenus elegans</u>	.	.	.	.	.	.	.	+	.	.	.	.	.	.	.	.

Table 5. Undergrowth data of the *Picea angustissima* and other sapropterid trees are indicated by +. Other data and abundance are obtained from topographic position, structure, and species having a coverage of less than 0.1% are indicated by +. If the species are present in the stand but not increasing basic conditions.

[illegible]

[illegible]

Stand number	21	22	24	34	48	82	52	59	29	10	31	81	35	36	39	40	75	76	23	80	86	44	70	1	28	56	57	92	93	71	38	43	72	42	32	73	88	90	91	33	37	41	87	89	74			
% Coverage	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	
% Frequency	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F	F
<i>Oenothera chilensis</i>	1.6				0.1								2.0	2.0		0.6	2.0		2.5			0.1					2.0			1.5					2.0	1.5	8.5				0.1		1.1	2.5				
<i>Oenothera depauperata</i>								2.0				0.6					2.0		2.0		2.0	2.0	2.0			2.0						0.6						1.0	1.5	0.1		0.6						
<i>Oenothera purpurea</i>		1.9															2.5									2.0																						
<i>Pedicularis racemosa</i>					0.1			2.0												2.0						2.0	2.0		2.0									8.6	2.0	2.5				2.0				
<i>Penstemon rydbergii</i>							2.0																																			2.0						
<i>Phlox multiflora</i>										2.0																																	2.0					
<i>Potentilla diversifolia</i>			2.0	2.0	0.1		0.4		0.1	2.5				2.0	2.0				2.0	1.4	0.1		2.0	2.0	2.0	1.5	0.2	1.5	0.1	0.4	2.0	2.0			0.1	2.0	0.3	0.1			2.0	2.0	2.0					
<i>Potentilla frons</i>																	0.1				2.0																									2.0		
<i>Pyrola secunda</i>			0.75	0.3			0.4					2.0	0.2	2.0	2.0	2.5	1.25	1.5		1.5	0.1	0.1		2.0	0.2	2.0	0.1	2.0		0.2	0.1												0.6	1.25	0.2			
<i>Pyrola virens</i>													2.0				2.5									0.2																					2.0	
<i>Ranunculus escholtzii</i>																									2.0		2.0																			0.7		
<i>Rosa acicularis</i>		2.4		0.1	0.4	1.5	0.1			2.0	2.5						1.25	1.5		2.5	0.1		0.1	2.0	2.2	1.5																0.1	0.7					
<i>Senecio integerrimus</i>			2.0				2.0		2.0								2.0				2.0		2.7	2.0					0.1						1.8			6.5			2.0							
<i>Senecio lucerna</i>																																																

APPENDIX II. Soils data of the upper dm of mineral soil  
of forest stands studied in the Bighorn Mountains.

Table G. Results of soils analyses of the upper 1 dm of soil from each stand. Stand data are arranged according to habitat types.

			Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
Stand	pH	C.E.C.	Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
(Textural Name)												
<u>Pinus ponderosa</u> - <u>Agropyron spicatum</u> habitat type												
2	6.1	10.1	9.18	1.53	0.39	.07	16.	.085	1.76	69.	20. (sandy loam)	11.
<u>Pinus ponderosa</u> - <u>Festuca idahoensis</u> habitat type												
5	6.5	15.4	16.9	3.15	0.63	.07	23.	.322	6.21	55.	36. (sandy loam)	9.
7	6.1	6.60	6.10	0.79	0.28	.03	32.	.143	3.45	81.	12. (loamy sand)	7.
<u>Pinus ponderosa</u> - <u>Juniperus communis</u> habitat type												
62	6.8	28.9	41.7	9.66	1.29	.07	6.0	.317	8.57	22.	52. (silt loam)	26.
<u>Pinus ponderosa</u> - <u>Spiraea betulifolia</u> habitat type												
3	7.4	33.5	40.7	2.28	1.01	.15	39.	.593	12.3			
63	6.1	14.1	13.4	4.29	0.58	.04	23.	.210	5.63	65.	28. (sandy loam)	7.

Table G, cont'd.

			Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
Stand	pH	C.E.C.	Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
(Textural Name)												
<u>Pinus ponderosa</u> - <u>Physocarpus monogynus</u> habitat type												
6	5.9	7.40	6.67	0.95	0.18	.03	11.	.148	3.65	83.	9.	8.
(loamy sand)												
8	6.6	22.7	19.9	4.15	0.77	.05	29.	.432	9.71	52.	36.	12.
(sandy loam)												
9	7.1	38.2	15.6	1.48	0.47	.04	8.0	.152	12.3	61.	22.	17.
(sandy loam)												
79	6.6	21.5	17.0	3.58	0.89	.08	6.0	.362	6.83	36.	37.	27.
(loam)												
<u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u> habitat type - <u>Juniperus communis</u> phase												
16	6.3	5.85	5.54	0.70	0.28	.05	13.	.096	2.33	82.	14.	4.
(loamy sand)												
64	6.5	25.8	20.5	4.89	0.96	.06	3.0	.168	5.05	21.	48.	31.
(clay loam)												
<u>Pseudotsuga menziesii</u> - <u>Mahonia repens</u> habitat type												
26	6.6	29.3	47.7	5.25	0.89	.09	12.	.469	11.5	34.	48.	18.
(loam)												
78	7.7	26.2	35.8	3.22	1.59	.10	42.	.206	7.02	26.	51.	23.
(silt loam)												
11	7.1	26.6	24.5	5.26	1.08	.08	42.	.364	8.98	29.	53.	18.
(silt loam)												

Table G, cont'd.

Stand	pH	C.E.C.	Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
			Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
										(Textural Name)		
12	6.9	34.7	46.0	7.29	1.21	.07	23.	.478	11.4	25.	52. (silt loam)	23.
13	6.6	21.7	18.3	4.14	0.85	.08	8.0	.198	5.60	19.	59. (silt loam)	22.
14	7.3	34.4	64.7	4.16	0.98	.09	16.	.427	10.0	28.	56. (silt loam)	16.
15	7.0	30.5	42.6	5.38	1.31	.08	42.	.532	9.92	21.	62. (silt loam)	17.
68	6.4	22.2	19.5	4.78	1.07	.04	9.0	.228	7.05	18.	61. (silt loam)	21.
<u>Pseudotsuga menziesii</u> - <u>Physocarpus monogynus</u> habitat type												
77	7.1	16.1	44.7	7.00	1.56	.11	23.	.763	11.4	20.	58. (silt loam)	22.
20	6.8	30.5	51.7	1.01	1.03	.07	5.0	.609	11.4			
70	7.1	25.9	40.9	3.12	0.83	.11	3.0	.253	7.28	29.	48. (loam)	23.
<u>Populus tremuloides</u> - <u>Lupinus argenteus</u> habitat type												
61	5.9	40.7	48.8	5.19	1.02	.39	21.	.718	11.3			
10	6.7	11.3	33.5	6.03	1.67	.08	63.	.828	12.3			

Table G, cont'd.

			Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
Stand	pH	C.E.C.	Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
(Textural Name)												
<u>Pinus contorta</u> - <u>Arctostaphylos uva-ursi</u> habitat type												
47	5.6	10.9	7.98	1.13	0.58	.04	51.	.015	4.50	46.	42. (loam)	12.
50	5.5	7.21	4.33	0.67	0.36	.04	10.	.047	2.30	55.	34. (sandy loam)	11.
51	5.5	8.60	5.69	1.00	0.42	.05	20.	.045	2.96	61.	30. (sandy loam)	9.
83	5.6	5.10	4.40	0.65	0.37	.10	13.	.053	1.71	50.	38. (loam)	12.
84	5.4	9.10	4.87	0.56	0.53	.07	33.	.082	3.81	46.	43. (loam)	11.
<u>Pinus contorta</u> - <u>Vaccinium scoparium</u> habitat type												
53	5.5	8.00	5.60	0.87	0.47	.03	30.	.105	2.59	55.	36. (sandy loam)	9.
85	5.3	10.8	4.65	0.74	0.52	.07	23.	.098	4.29	59.	32. (sandy loam)	9.
69	5.7	25.6	15.0	3.40	0.78	.15	28.	.274	7.91	28.	56. (silt loam)	16.
67	5.3	17.5	11.0	1.96	0.74	.06	21.	.192	5.57	24.	61. (silt loam)	15.
60	5.3	15.0	7.35	1.39	0.71	.07	60.	.146	4.05	34.	50. (silt loam)	16.

Table G, cont'd.

Stand	pH	C.E.C.	Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
			Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
										(Textural Name)		
58	5.2	11.8	5.36	0.97	0.52	.04	39.	.103	4.33	44.	46. (loam)	10.
54	5.4	10.5	5.88	0.91	0.50	.03	48.	.084	6.76	57.	33. (sandy loam)	10.
49	5.4	9.80	6.10	1.09	0.52	.05	21.	.100	3.88	42.	50. (loam)	8.
46	5.0	15.6	6.19	1.11	0.53	.10	99.	.018	4.39	45.	43. (loam)	12.
45	5.3	12.0	7.16	0.37	0.73	.04	69.	.203	5.57	47.	42. (loam)	11.
25	5.0	13.3	4.87	0.66	0.48	.03	60.	.166	5.86	52.	36. (sandy loam)	12.
<u>Picea engelmannii</u> - <u>Vaccinium scoparium</u> habitat type												
21	5.5	15.9	10.9	2.91	0.42	.03	41.	.306	10.1	42.	45. (loam)	13.
22	5.0	20.5	12.2	2.06	0.47	.03	13.	.444	12.3	47.	39. (loam)	14.
24	5.0	16.4	6.48	1.12	0.53	.04	93.	.203	6.76	36.	47. (loam)	17.
34	5.4	14.7	9.11	1.33	0.29	.12	34.	.150	6.56	17.	65. (silt loam)	18.

Table G, cont'd.

Stand	pH	C.E.C.	Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
			Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
										(Textural Name)		
82	5.6	7.7	4.44	0.54	0.39	.07	20.	1.98	0.57	50.	40. (loam)	10.
52	5.4	13.1	8.49	1.25	0.50	.06	78.	.155	3.50	57.	34. (sandy loam)	9.
55	5.7	16.3	10.7	1.65	0.72	.07	34.	.148	7.12	36.	52. (silt loam)	12.
29	5.0	21.5	9.36	1.78	0.83	.08	45.	.252	8.76	32.	53. (silt loam)	15.
30	5.0	17.3	7.58	1.19	0.64	.07	35.	.216	6.79	35.	50. (loam)	15.
31	5.0	34.2	8.36	1.06	0.62	.07	38.	.202	7.41	34.	50. (silt loam)	16.
<u>Abies lasiocarpa</u> - <u>Shepherdia canadensis</u> habitat type												
75	5.7	16.5	9.17	1.23	0.97	.08	93.	.161	5.98	41.	22. (clay loam)	37.
76	5.5	13.8	6.99	0.97	0.70	.08	78.	.121	4.30	39.	51. (silt loam)	10.
<u>Abies lasiocarpa</u> - <u>Vaccinium scoparium</u> habitat type												
81	5.4	12.8	6.42	0.87	0.50	.07	45.	.106	2.82	23.	57. (silt loam)	20.
35	5.1	53.5	11.1	3.94	0.60	.07	35.	.185	6.78	17.	59. (silt loam)	24.

Table G, cont'd.

Stand	pH	C.E.C.	Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
			Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
										(Textural Name)		
36	5.1	17.9	9.01	2.29	0.49	.06	51.	.190	6.94	18.	61. (silt loam)	21.
39	5.2	31.3	14.4	1.86	0.87	.10	51.	.190	5.18	27.	45. (clay loam)	28.
40	4.9	13.3	6.38	1.46	0.40	.08	45.	.180	5.94	23.	58. (silt loam)	19.
23	5.0	18.2	8.87	1.26	0.60	.03	42.	.322	11.1	53.	36. (sandy loam)	11.
80	5.4	23.4	12.0	1.80	0.55	.12	39.	.170	4.71	32.	42. (loam)	26.
86	5.4	13.4	5.34	0.72	0.56	.09	81.	.074	2.37	45.	42. (loam)	13.
44	5.1	10.0	5.20	0.92	0.53	.05	48.	.126	4.42	44.	45. (loam)	11.
59	5.5	27.0	14.1	0.58	0.66	.21	20.	.313	8.82	30.	52. (silt loam)	18.
1	5.5	21.8	13.0	2.42	0.61	.24	22.	.227	7.78	41.	48. (loam)	11.
28	5.0	15.6	9.47	1.29	0.41	.07	10.	.184	7.52	45.	40. (loam)	15.

Table G, cont'd.

Stand	pH	C.E.C.	Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
			Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
										(Textural Name)		
56	5.6	17.6	15.9	2.15	0.47	.08	11.	.206	7.73	31.	53. (silt loam)	16.
57	5.0	18.4	7.75	1.37	0.55	.10	29.	.218	6.13	28.	58. (silt loam)	14.
92	5.0	17.1	3.89	0.60	0.36	.17	19.	.177	5.21	30.	50. (loam)	20.
93	5.3	12.6	4.50	0.73	0.41	.07	60.	.119	3.76	41.	47. (loam)	12.
71	5.8	31.8	23.9	3.20	0.52	.15	15.	.262	7.54	14.	59. (silt loam)	27.
38	5.3	8.7	12.2	3.32	0.63	.12	51.	.173	6.36	21.	58. (silt loam)	21.
72	5.1	21.3	8.70	1.51	0.47	.12	41.	.155	5.40	20.	54. (silt loam)	26.
42	4.9	39.4	5.88	1.15	0.53	.09	45.	.188	7.50	42.	45. (loam)	13.
32	4.9	18.2	5.85	0.58	0.37	.07	81.	.153	5.18	57.	34. (sandy loam)	9.
73	5.7	26.4	20.2	0.83	0.52	.11	45.	.220	6.35	21.	56. (silt loam)	23.
88	5.5	24.4	13.9	3.70	0.61	.11	14.	.177	5.88	15.	60. (silt loam)	25.

Table G, cont'd.

Stand	pH	C.E.C.	Exchangeable bases, meq/100 g				P,			Mechanical Analysis		
			Ca	Mg	K	Na	ppm	% N	% O.M.	% Sand	% Silt	% Clay
										(Textural Name)		
90	5.4	25.4	17.2	1.72	0.53	.13	13.	.158	5.66	18.	58. (silt loam)	24.
91	5.3	18.9	11.2	0.46	0.40	.13	32.	.122	3.91	18.	58. (silt loam)	24.
<u>Abies lasiocarpa</u> - <u>Arnica cordifolia</u> habitat type												
33	6.3	23.3	45.5	4.21	0.85	.16	27.	.275	9.44	24.	54. (silt loam)	22.
43	6.0	37.8	53.2	2.35	1.08	.12	24.	.431	9.59	20.	42. (clay loam)	38.
37	5.9	17.8	44.4	4.15	0.67	.10	4.0	.285	12.0	26.	53. (silt loam)	21.
41	5.9	21.1	69.3	1.75	1.18	.18	.19	.335	12.8	21.	49. (clay loam)	30.
87	5.1	29.1	24.6	0.92	0.90	.11	23.	.220	7.94	21.	46. (clay loam)	33.
89	6.5	41.5	54.8	0.66	0.54	.19	18.	.337	9.93	26.	52. (silt loam)	22.
74	6.6	52.4	65.5	1.14	0.61	.14	17.	.403	12.5	18.	45. (silty clay loam)	37.